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ON THE MOUNTING OF LARGE TELESCOPES.

By Prof. GEO. E. HALE.

EVERYONE interested in the mounting of large telescopes will see in Sir Howard Grubb's paper, in your May number, a most valuable contribution to the literature of the subject. It seems likely that we are soon to be brought face to face with the problem of devising suitable mountings for instruments of great aperture, and the novel modification of Dr. Common's flotation method, described in the article referred to, contains features which commend it at once. At the same time it is not without disadvantages, but whether or not these are to be regarded as serious, experiment can best decide.

It is hardly to be doubted that Sir Howard is right in looking to the reflector as the most promising means of furnishing greatly increased light-grasping power. Such able opticians as Brashear and Clark have told me that they are ready to make objectives of as great aperture as the optical glass furnished them will allow, and during a recent visit to Jena I found Dr. Schott confident that he could soon make discs of hitherto impossible size. Nevertheless, an aperture of sixty inches is the largest I have ever heard of discussed for an objective, while Dr. Common has at least two mirrors of this size, not to mention Lord Rosse's great instrument. In default of glass, speculum metal could be used, and I feel certain that Brashear would undertake a mirror of ten feet aperture.

It is apparently only too true that for many classes of work the reflector is inferior to a refractor of the same or even much smaller aperture, but we may at present consider only such problems as require for their solution an instrument of great light-grasping power. I quite agree with Sir Howard that "the chief hope of progress in astronomical research lies undoubtedly in the application of photography," and the great telescope under consideration should most certainly be capable of being used for this purpose. But the possibility of photographing a field of stars or nebulæ at the focus of the instrument, while most eminently desirable, is not the only advantageous use to which a large instrument could be put. Indeed, I venture to believe that the employment of such a large telescope for the photography of stellar spectra would be of even greater value in the advancement of science than the results to be obtained by ordinary photographing in the principal focus; for so fruitful is the study of the spectra of the brighter stars with small telescopes, that a far more abundant harvest may be expected when greatly increased apertures bring the countless number of fainter stars within reach. In the case of the brighter stars, the manifold increase of dispersion made possible by the gain in light would render still more accurate than at present the measure of motions in the line of sight, and the spectroscopic method would become a hopeful means for the determination of the solar parallax. But the importance of stellar spectroscopy is too evident to require discussion, and I will merely point out one practical reason for designing the telescope with this end in view. If the definition of the instrument from any cause should turn out to be defective, unsuiting it for direct visual or photographic work, it might still be of great service in spectroscopy, especially with a spectroscope having a long collimator. Thus, if the telescope be of a design suitable for spectroscopic work, its construction need hardly be looked upon as an experiment, for the probability that it would not suffice for this purpose is very small.

If the desirability of constructing the telescope for spectroscopic work be admitted, the focal length must certainly be much longer than that chosen by Sir Howard Grubb. With a spectroscope of given aperture, the brightness of a star's spectrum is independent of the focal length of the large telescope. If we choose a collimator of about twenty-four inches focus, and give it an aperture of two inches (more than this would hardly be advisable, on account of the great size and weight of the prism-train), we have a ratio of one-twelfth. With an aperture of ten feet the great reflector would thus have a focal length of one hundred and twenty feet. In any case I hardly think a ratio greater than one-tenth would be advisable from a spectroscopic standpoint. Sir Howard has chosen a ratio of about one-fifth, giving a focal length of fifty feet for an aperture of ten feet. Doubling the length of the tube would certainly render the problem of mounting the instrument much more difficult, but this very increase emphasizes the necessity of employing some such method of supporting the tube as that devised by Sir Howard Grubb.

One of the greatest defects of all forms of telescope mounting at present employed is the method of supporting the tube at a single point, which is usually near the centre. In small instruments the difficulty is not felt, but as the focal length and weight of the objective increase, the question becomes serious. In the case of the forty-inch Yerkes telescope the objective will weigh about five hundred pounds, and the solar spectroscope nearly half a ton. These weights (with additional counterpoise at the objective end) will be carried at the opposite ends of a

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steel tube sixty-four feet long, supported at the centre by the great declination axis. Messrs. Warner and Swasey have done their work so well that we fear no serious flexure, but a certain small amount must be expected. If the aperture were trebled and the focal length doubled, a single support would hardly be sufficient.

With a reflector the conditions of the problem are quite different, as the mirror comes at the lower end of the tube. I have queried whether a slight modification of Dr. Common's mounting for his five-foot reflector would suffice for double the aperture and a much greater increase in focal length. As the mounting is constructed, the polar axis is a great cylindrical steel vessel so weighted as to float at the proper inclination in a tank of water. The declination axis is near the lower end of the short telescope tube, which is supported by it within a fork projecting from the upper end of the polar axis. As the tube is very short and light, the mounting is a very suitable one. If the fork were closed into such a form as that shown in the drawing of Sir Howard Grubb's model, and the upper end of the polar axis perhaps floated in a second tank, a long tube supported near its middle point might be carried fairly well, the range in declination being about the same as in the case of the instrument described in KNOWLEDGE. But as compared with the latter this telescope would have, in common with most other instruments, a number of serious disadvantages.

In the first place, the tube would be so supported as to show a marked effect of flexure due to its own weight. In Sir Howard Grubb's instrument the flexure of the lower portion of the tube would be very small, and that of the portion of the tube above the declination axis would also be small on account of its comparatively short length. There would, however, be a flexure produced by the resistance of the water to the motion of the tube when driven by the clock. It would be an important advantage if the driving power could be applied directly to the lower end of the tube, but on account of the motion in declination this is probably impracticable.

Again, the motion of the eye-end would be very great. In the case of a great refractor like the Yerkes telescope, the floor (seventy-five feet in diameter) of the observing room must be arranged to rise and fall through a distance of twenty-two feet. This seems unavoidable with a refractor, but Sir Howard's plan reduces the motion of the eye-end of an eight-foot reflector to so small a quantity as to make it always accessible by very simple and inexpensive means. For a ten-foot reflector of one hundred and twenty feet focal length the motion of the eye-end would necessarily be greater, but there would probably be no great difficulty in following it on a movable stage with stairway, or the observer might readily be carried on the telescope tube itself. But bearing in mind the purposes for which the instrument is designed—photography and stellar spectroscopy—this difficulty could easily be avoided. I would mount the spectroscope on the end of the tube, with the slit at the focus of the great mirror and the axis of the collimator coincident with the axis of the reflector.

The slit jaws should be polished, and inclined so as to make a small angle with the focal plane. A reflecting prism and telescope, supported near the centre of motion of the reflector, would enable the observer to keep a star on the slit. This device, which has been used by Dr. Huggins for years, is much superior to any other method of maintaining a star on the slit. For the second important use of the reflector the spectroscope slit could be pushed up out of the focal plane, to give place to a carrier for photographic plates. A small mirror, attached to the outer edge of the carrier, and adjustable in position, would make possible the observation of a star outside the field being photographed, with the small telescope used for a similar purpose with the spectroscope. Thus, in both cases the observer could stand near the centre of motion, and keep a star on the slit or cross-hairs for hours. It would be necessary to reach the upper part of the tube only for the purpose of inserting the plate-carrier, and for visual observations.

Another difficulty of ordinary mountings is the necessity of providing a very large and expensive dome to cover them. The dome fulfils a double purpose; it protects the instrument against the weather, and shields it from the wind during observation. The second point is perhaps of more importance than the first, for a large telescope might be so constructed as to suffer little from the weather, its more delicate parts being covered. As for the wind, a wall like that shown in Sir Howard Grubb's drawings would sufficiently protect an instrument three-fourths of which is under water. If a dome were desired, a comparatively small one would suffice. The great saving of expense on the dome and rising-floor is an important argument in favour of this form of mounting.

Of the possible disadvantages which Sir Howard Grubb has enumerated and discussed. it seems to me that the first is the only one to be regarded as at all serious. Considering its size and the immense number of interesting objects within its reach, the limited range of the reflector is no very great objection. The friction of the liquid would probably render the setting rather slow, but such a telescope is not designed to swing quickly about from one object to another. It could better be employed a whole night on one or two fields. As to the currents created in setting the instrument, they would certainly be of brief duration, and may therefore be disregarded. But the difficulty arising from the difference in temperature between the liquid and the air is a more troublesome matter. That the definition would be affected, and, worse still, the mirror dewed if the air were warmer than the liquid, must be expected. The remedies proposed might serve to remove these difficulties, but I am somewhat sceptical about the advisability of warming a mirror at the back. It might be well to employ a double system of pipes for heating and cooling, so controlled by a thermostat as to keep the liquid very nearly at the temperature of the outside air. I should still retain the proposed double tube, with the constant circulation of air; but even if every such precaution were taken, much trouble from dewing of the mirror might still be feared. Heating the mirror at the back, *if it could be managed so as not to interfere with the definition*, would probably be the most effectual remedy for dewing. It is hardly necessary to add that, in our northern latitudes, some liquid of lower freezing-point than water would have to be employed.

INSECT SECRETIONS.—III.

By E. A. BUTLER, B.A., B.Sc.

(*Continued from page* 123.)

MOST people have probably noticed at some time or other certain small, dark bodies shaped something like mussel-shells, which are not unfrequently to be seen adhering to the skins of oranges or apples, or to the twigs and branches of apple and pear trees, but few would suspect them to be of insect origin. Yet such is the case, for in these "mussel-scales" we have examples of the family *Coccidæ*, or scale-insects, and it is in this family that we are to find our next examples of insect secretions. Amongst the *Coccidæ* there

is the most extraordinary difference between the adult male and female insects. They are, to begin with, all small creatures, some very minute. The males are provided with a single pair of wings, which in itself is an exceptional circumstance, since they belong to an order—the Homoptera—the members of which are normally four-winged. Thus they remind us of the two-winged flies, or Diptera, and the suggestiveness of their appearance is strengthened by the fact that they possess a pair of short hooked appendages where we might expect hind wings, by which we are at once reminded of the "balancers" of flies. Nevertheless, their general aspect is so different from that of the majority of dipterous insects, that they are hardly likely to be mistaken for members of that order, especially as they usually carry a pair of long bristles as a sort of tail. (See accompanying plate.)

In the organization of these little males everything is sacrificed to the one purpose of their life, that of reproduction, and such other functions as may be more or less accessory to that, as, for example, sight and locomotion. Thus we find that the mouth organs are atrophied, the digestive apparatus shrivelled up, and that part of the body which usually lodges the stomach and intestines contracted to very small dimensions. They take no food, and necessarily, therefore, live but a very short time. On the other hand, they have an excellent supply of eyes, the usual masses at the sides of the head being supplemented by two large additional eyes on its upper surface, and this superabundance of the means of sight must be of considerable advantage in their search for mates. They are themselves not so well known as their partners, and in many species have not yet been discovered at all. As a consequence, it is evident that parthenogenesis must frequently take place.

The fully-grown females are about as different as could well be imagined. They have no power of flight—nor, indeed, of locomotion of any kind, for in their adult form everything is sacrificed to the nutritive and reproductive functions, since they are destined to be great feeders and mothers of large families. As they are not required to go in search of mates, but enjoy the honour of being themselves sought out, and have nothing to do but wait to be wooed and then settle down to their maternal functions, means of locomotion and organs of sense are alike superfluous. Accordingly we find that antennæ and legs all ultimately disappear, while the mouth organs become highly developed, the piercing beak being sometimes six times as long as the rest of the insect. When fully grown, they seem to be little more than minute, inert lumps of flesh, the animal nature of which is by no means obvious to the naked eye till they are crushed.

The different species have the power of secreting materials of various kinds, which, on exuding from their bodies, form in most cases variously shaped scales, under which the insect is to be found. The "mussel-shells" mentioned above are examples of these scales. There are many different species, and their scales are of varied forms and colours, the majority being more or less oval or linear. Those that will produce males are both differently shaped and differently coloured from those that will develop into females. They are often found on the leaves as well as the branches of plants, each species having its own distinct kind of food-plant. One very common species which proves itself a great pest in conservatories is found on the under side of the leaves of the oleander, especially along by the side of the midrib, where it forms oval, convex, orange or brownish scales. It is from these scale-like coverings that this particular section of the Homoptera have been called "scale-insects."

The glands by which the material of the scales is secreted lie, according to Mr. A. Morgan, on the upper surface of the hinder part of the abdomen, and are sometimes very numerous; they are tubular, and open by small pores in the skin. The exudation from them is of a very varied character. Sometimes, as we have seen, it forms a distinct scale, which shelters the insect beneath; sometimes it is in the form of cottony or silky threads, which may remain adherent to the body, or may be deposited as a covering for the eggs. Or, again, it is of a waxy nature, as is the case with the maker of the Chinese insect wax of commerce, a species of *Coccus* nourished on a kind of ash tree. The insects that form this secretion suck up the sap of the tree to such an extent that they ultimately become almost entirely converted into masses of wax, which encrust the branches. This wax, when separated from the branches, is melted over a slow fire and then poured into cold water, by which it is washed and at the same time solidified into flakes. These are again melted and cast into cakes, and the wax then appears as a hard, translucent, crystalline substance, something like spermaceti. It is used for a variety of purposes in the East, especially for making candles and in the practice of medicine. It must be carefully distinguished from Japanese wax, which is also used for candle-making, but is a purely vegetable product obtained direct from the fruits of certain trees, and not elaborated from plant juices through the medium of an insect's digestive and secretory apparatus, as is the case with the Chinese product.

Several other of these *Coccidæ* yield valuable products, of which they are either directly or indirectly the originators. For example, the splendid scarlet dye called cochineal is derived from a species which is cultivated on cactus plants in Mexico, Madeira and elsewhere. The wingless and legless bodies of the female insects are collected and dried, when they look something like seeds; and from these the dye is obtained. The substances called "lac" and "manna," again, are produced as exudations on certain trees by the punctures of other species of scale-insects, the former on a kind of fig tree and the latter on tamarisk. The lac, while still adhering to the branches, is called stick-lac, but after separation and various degrees of refinement it is known by the names of seed, lump, and shell lac, the latter being the form in which it is most familiar to the British public.

The life-history of insects belonging to this group is generally somewhat as follows. The young larvæ, when just hatched, are furnished with the usual insect appurtenances, and are more or less active; but they soon attach themselves to the leaf or bark, become modified in form, and begin to grow a scale. The female casts its skin twice, but the male only once. The cast skin is to be seen either in the centre or at one end of the scale, fastened there by the secretion of which the scale is composed. After a time, the insect changes into a chrysalis, which again is peculiar, for the rest of the Homoptera do not exhibit a complete metamorphosis, but are active throughout life. The female deposits her eggs, which are numerous, under the scale, just behind her own body, and having done this she dies, leaving her shrivelled body just where it was. The adult insect is often much smaller than the larva which yielded it, and this shrinkage of course leaves room for the eggs and young insects under the scale, until the latter leave the parental roof and settle down elsewhere by pushing their beak-bristles into the plant as a permanent anchor and suction apparatus. Sometimes there is not only the rounded scale on the insect's back, but in addition to this a flat one, very much thinner than the other, is formed underneath the body.

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On removing the creature from the plant to which it is attached, the under scale often remains behind and appears as a thin film on the leaf. When the insect dies, its upper scale after a time falls off, but the under film still remains attached, to attest the former presence of the insect; and in this way relics of two or three generations, which have succeeded one another, may be found on the same area.

The life of a female *Coccus* is about as uneventful as one can well imagine; and in this respect it is a fitting accompaniment of a degree of degradation in structure which is almost without parallel amongst insects. If one felt inclined to moralize on the subject, one might well adopt the quaint words of an old naturalist writing a century ago about one of these scale-insects that is to be found on rose trees. He closes his paper with the words: "This is the biography of a creature whose world consists of two inches of a little branch of a rose bush, and it accomplishes what most men do: being born, multiplying itself, and—dying." The sluggish habits and semi-vegetative life of these degraded female *Cocci* render them peculiarly liable to the attacks of parasites of various kinds, and, amongst others, parasitic fungi have been discovered upon them. Some of these appear to attack them during life, but others locate themselves on their dead bodies, deriving their nourishment from the carcase. Of course all such fungi are exceedingly minute, but still some very beautiful forms are sometimes to be met with. In his "Vegetable Wasps and Plant Worms," Dr. M. C. Cooke figures one, of which we reproduce a sketch (Fig. 6), showing three pretty little clubs rising up from the surface of the convex scale.

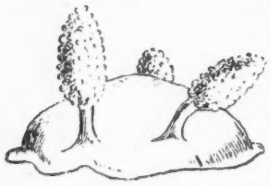

Fig. 6.—Scale-insect, with parasitic fungi. Much magnified. (After Cooke.)

Two other genera of this remarkable group of insects may be referred to as forming their waxy or silky secretions into different shapes from those mentioned above. The first of these is *Eriopeltis*. This forms little compact oval tufts, like pieces of cotton wool (Fig. 7) attached to the stems and blades of certain grasses, and there is certainly nothing whatever in their external appearance to suggest any connection with insects, unless, indeed, they might be cocoons of small ichneumon flies. But a close examination, revealing a number of separate threads standing out in all directions, would soon dispel this idea, and would leave their real nature as problematical as ever. Though apparently not uncommon, they have not long been generally known in this country, having previously, no doubt, been overlooked, partly because of the little attention that was until recently paid to the *Coccidæ*, and partly because of the completeness of their disguise. They seem to have been first noticed in this country in 1856, when there is a reference to them in "The Proceedings of the Entomological Society of London"; but that was soon forgotten, and they passed out of knowledge till 1885, when Mr. G. C. Bignell again called attention to them.

Fig. 7.—*Eriopeltis festucæ*, on blade of grass.

The other genus is called *Orthezia*, at least one species of which is a common and widely distributed insect (Fig. 8), though, as it is of retiring habits, it is not likely to be frequently seen except by those who specially look for it. The whole body is invested in the waxy secretion, and no parts of the real insect are visible except the legs and antennæ, which project from the waxen coat which envelopes the whole. There is also the further peculiarity that the exudation is not irregularly disposed in the form of loose threads, but is perfectly symmetrically arranged in the form of fluted columns and rosettes, so rigid and so exquisitely chiselled as to give the insect the appearance of being a little marble statuette. On the fore part the white secretion is arranged in a sort of rosette, and behind in parallel longitudinal lines, reminding one of stiffly arranged folds of drapery. Underneath, the surface is strongly convex and smooth, forming the outer boundary of a kind of pouch in which the eggs are carried. On seeing the insect from above, it appears simply to be an exquisitely neat cast in plaster of Paris, and there is nothing suggestive of a living being at all. On turning it over on its back, one is much astonished to find that the supposed mineral is provided with six little brownish legs, which by their movements show the thing to be alive; and there is then irresistibly suggested the idea of an imprisoned being enclosed in a perfectly rigid shell of plaster of Paris, with minute holes for the legs to come through, and one is apt to think that some misfortune must have happened to the creature to bring it into such a condition. The condition, however, is a perfectly natural one, and the insect may be found thus covered in all its stages amongst dead leaves and other rubbish. While it is young, little more than the rosette is developed, and the egg pouch is not added till the insect becomes fully grown. It is only the female insect that appears in this curious form; the male is a small winged creature, with a single pair of wings and a number of tufts from its tail, like spun glass.

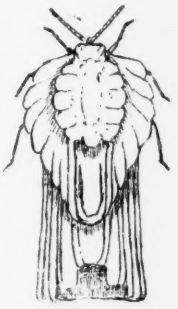

Fig. 8.—Adult female of *Orthezia urticæ*. Magnified eight diameters.

The aphides are closely allied to the *Coccidæ*, and amongst them too we find instances of the secretion of masses of protective matter, which are employed to shelter both old and young insects. Perhaps the best known example of this is to be found in the "American blight," or "woolly aphis," that sometimes infests apple trees. A badly infested tree will look as if its branches had had masses of cotton wool scattered about in all directions over them. The cottony substance will be found specially thick round crevices in the bark, or on places whence boughs have been removed in pruning or accidentally broken off, and occasionally it hangs down from the branches to the depth of several inches as loose masses, which wave about in the wind and are sometimes blown away on to the neighbouring trees. A cursory glance will probably fail to detect the insects, so completely are they concealed by the masses of down they secrete, and the white threads will very likely be set down as a sort of fungus. On turning it aside, however, the insects will be discovered in the midst of the mass as yellowish or reddish, wingless, fat-bodied, six-legged beings, of various sizes according to age. They differ from the majority of aphides in not possessing the two tubes which usually project from the hinder part of the body for the secretion of the honey-like liquid of which ants are so fond. Being deprived, however, of that secretion, they have all the more fully developed the power of exuding the protective cottony mass. In speaking of this secretion as "cottony," it will of course be understood that its appearance only, and not its constitution, is referred to. If its real nature were to be indicated by a name, the epithet "silky" would be

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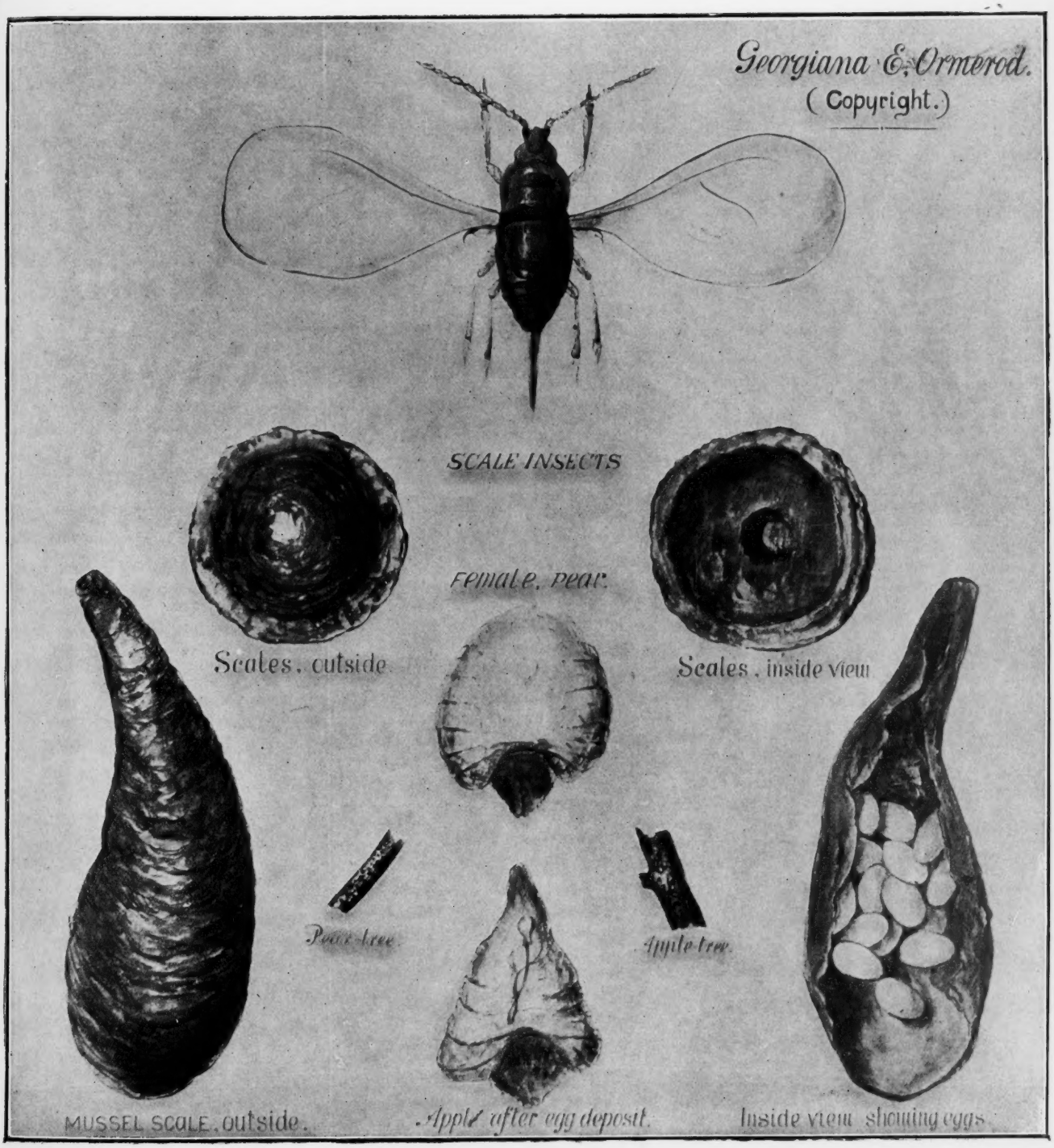

SCALE INSECTS.

A winged male is shown above. Its single pair of wings should be noted, and below them the hooked projections described in accompanying paper. In the centre, below, are two females, the upper, from pear tree, distended with eggs; the lower, from apple, after eggs have been laid. At the sides are outer and inner views of a circular scale and a "mussel-scale." The inner view of the latter indistinctly shows shrivelled body of female above, and plainly eggs below. Small portions of pear and apple twigs are shown between these and the female insects, with the scales of the natural size.

From a Photograph of Miss Ormerod's drawing, by Messrs. Newton, of Fleet Street.

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a more correct term, as its properties are more like those of silk than of any other substance.

These cottony or silky masses must be extremely useful to the insects, both as a means of protecting them from birds and other predatory creatures, and of assisting their migrations, for when any of the loose masses are blown from one tree to another there are sure to be some insects in them, and these are thus rapidly introduced to new and more extensive pastures from which their own unaided and feeble powers of locomotion would have completely excluded them. Their attacks upon apple trees are much more serious in results than might have been anticipated from the size of the insect. It is not merely that they abstract a good deal of sap from the growing tree, thereby reducing its vitality, but their punctures give rise to a diseased condition of the wood beneath, which becomes soft, pulpy, and swollen, so that the bark splits and exposes fresh surfaces to attack. At the end of summer these moist tumours dry up and thus deepen the cracks, affording both safer anchorage and still more abundant pasturage for a new host of destroyers.

Many remedies have been suggested against these formidable pests. As the insects do not of their own accord wander much, anything that cuts off the supply of food in the spot in which they are located will be useful; or, again, anything that clogs up their breathing apertures, which are at the sides of the body as usual, will prove efficacious by suffocating them. Hence washes of some sort or other are the best kind of remedies, and any lotion in which soap forms a principal ingredient seems to be the most satisfactory in results. There is frequently a little difficulty in applying such remedies, in consequence of the tendency the insects exhibit to lurk in minute crevices, where it is difficult to get at them with any brush that is large enough to be used where great numbers are concerned. Fortunately, the insects soon give evidence of their presence by the snow-white appearance of the cottony down proceeding from them, and as prevention is better than cure, especially in such a case as this, every effort should be made, as soon as the tell-tale flecks appear, to rid the trees of their parasites, and massacre the whole tribe before they have time to follow the characteristic tendency of their race, and multiply indefinitely.

A similar secretion, though in much smaller quantity, is formed by those aphides that live beneath the soil and feed upon the juices of underground stems and roots. In this case the waxy material coats their bodies as a sort of mealy powder, and gives them the appearance of having been dusted over with flour. As the secretion is impervious to moisture, it serves the insects in lieu of a waterproof garment, and keeps them dry, notwithstanding the moistness of their surroundings.

The same order of insects, viz., the Homoptera, contains yet another group in which the power of secreting silky or waxy fibres is developed. These are a particular family of the frog-hoppers, which are so called from their wonderful jumping powers. The family in question is called *Cixiidæ*, and its British representatives are few in number, though two of those few are amongst our common insects. These are called *Cixius nervosus* and *C. pilosus*. They have brownish black bodies and four transparent glassy wings, and the nervures of the front pair are distinctly studded with black dots. The small head ends in a beak, which is bent under the body in repose, and the thorax is furnished with three longitudinal keels. The hind legs are considerably longer than the other two pairs, and it is with these that the insects perform their astonishing leaps. In repose the fore wings are placed along the sides of the body, and completely conceal the hind pair, so that the shape is something like that of a small moth at rest. Seeing one of these insects sitting thus on a leaf, you go to pick it up with your fingers, but just as you are about to lay hold of it, it vanishes from sight as suddenly and as utterly as if it had been gifted with the property of rendering itself invisible at will. The explanation is that it has suddenly leapt away with a vigorous stroke of the hind legs, aided by the wings, which are simultaneously outspread, and the movement is so sudden and unexpected that it is rarely possible to tell in what direction the creature has gone.

Cixius pilosus (Fig. 9), the smaller insect, which is not quite half an inch in expanse of wings, is, of the two, the more noted for the development of the cottony flocks at the end of the body. They very strongly suggest the idea of a parasitic fungus, and in fact a similar structure in an American species was once described as such. This was in 1769, when Fougeroux de Bonderoy submitted to the French Academy a paper descriptive of insects on which plants were to be found growing—an association of dissimilar organisms which was a great puzzle to the older naturalists, and led some of them to the conclusion that "the passage and mutation of animal species into the vegetable, and reciprocally from the vegetable to the animal," was not merely a possibility but even a frequent occurrence! After having cited a number of genuine instances of fungoid plants growing on the bodies of insects, the author proceeds to describe a growth on the body of one of the Cicadaria—that particular group of insects with which we are now specially concerned. The insect, he says, "is a native of Cayenne, and the plant is a species of fungus, but different from those we have described. It is formed of long and silky filaments, which cover the whole body of the insect, and project about seven to eight lines above and below the belly of the animal." But from the figure that accompanies the description, it is evident that what he had before him was nothing more than filamentous exudations similar to those of our own *C. pilosus*, though on a rather larger scale. Many other exotic species of this order, especially those belonging to the group of "lantern-flies," produce large masses of similar white tufts and threads, which cover more or less of their bodies, and give them a mouldy appearance. (*To be continued.*)

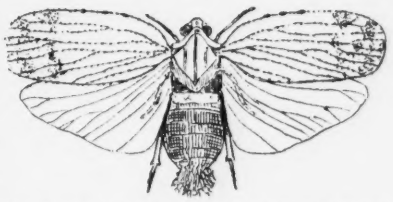

FIG. 9.—*Cixius pilosus*, with cottony filaments at tail. Magnified five diameters.

LIQUID AIR.

By J. J. STEWART, B.A.Cantab., B.Sc.Lond.

IT is a familiar fact to all that some substances can be obtained in the varying forms of solid, liquid and gas; but many substances come under our notice only when occupying one of these states. When granite is mentioned we at once think of a hard, solid rock; few people have seen granite in a liquid state. Again, the name *mercury* calls to our mind the well-known liquid metal. So there are numerous gases and vapours which are known to us only under this somewhat impalpable and less tangible form. Amongst the substances familiarly known to us, however, there are a large number which, through the action of heat upon them, can be

readily changed into a fluid and then into a vaporous state. Perhaps the best known of all is water, though even this in hot climates is rarely seen in the there uncommon solid form; so that the African chief, who had accepted many statements from his European visitor, utterly refused to believe him when he was told that, owing to the intense cold in some countries, rivers got hard enough to be walked over.

Lately, in many text-books of science, gases were divided into two classes—those which could be liquefied by the application of cold, or pressure, or both, and those which were *permanent*, or were known to us only in the form of gases. It was suspected by scientific men, especially after the extensive experiments by Faraday, who succeeded in liquefying many of the "permanent" gases, that all gases without exception could be changed into the liquid form if they were exposed to a sufficiently great pressure and at the same time cooled down far enough. This surmise has been proved correct only within comparatively late years, and now all gases, including the air we breathe, must be considered as differing from vapours, such as steam, only because at the usual temperatures at which we generally deal with them they are in a condition similar to that which other substances attain when heated to a very high temperature.

I propose to give a short account of the work hitherto done in the liquefaction of gases, commencing with that so ably carried out by that unsurpassed experimenter Michael Faraday, and going on to refer to the researches commenced by Raoul Pictet and by Caillelet in France, who, about the same time (1877), succeeded in liquefying oxygen and even hydrogen. These researches were pursued by Wroblewski and Olzewski in Russia, and have been continued lately in our own country by Prof. Dewar, who, with such striking success, has liquefied air in large quantities, and has even handed it about in pint bottles for inspection by a large audience.

There are two means open to us of liquefying a vapour. Let us increase the pressure upon it, or lower its temperature, and if we proceed far enough in these operations the vapour will become liquid. A further condition is necessary with the "permanent" gases—we must cool them down below their *critical temperature*. This critical temperature is that above which no amount of pressure applied to the gas will be capable of changing its state into that of a liquid.

Faraday, in his series of experiments, applied the simple but effective means of generating the gas, in a strong glass tube, from those compounds which evolved the required gas on heating. In this way the gas, being produced in a limited space, produced a great pressure, under which pressure of its own vapour the gas became a liquid. On breaking the tube the gas, compelled by pressure to exist as a liquid, would revert to the form natural to it at the temperature of the experiment, and would do this with explosive violence. There was thus always a tendency for the gas to burst the tube, and this sometimes occurred during Faraday's experiments. Hence he was careful to wear a mask made from wire gauze or thick glass, but even thus he did not entirely escape injury. Faraday immersed one end of his tube in a freezing mixture while the other was exposed to heat. In this way he succeeded in liquefying a large number of gases, and examined their properties while in this unusual state. Amongst the gases so treated were the following:—carbonic acid, hydrochloric acid, sulphur dioxide, cyanogen, ammonia, and chlorine. He carried out his first set of experiments on this subject in the year 1823. Later, in the year 1845, after Thilorier had shown how carbonic acid gas could be obtained in the liquid form on a large scale, and also as a solid, Faraday used the solid carbonic acid mixed with ether, and by means of the cold produced by the evaporation of the mixture he reduced the temperature to about $-100°$ Cent., and obtained most of the above-mentioned gases, and also nitrous oxide, not only in a liquid but also in a solid state. Hydrochloric acid, hydrogen arsenide, ethylene, silicon fluoride, boron fluoride, and chlorine he at this time managed to get in the liquid form, but was unable to solidify these substances. The gases hydrogen, oxygen, nitrogen, nitric acid, carbon monoxide, and marsh gas resisted all Faraday's attempts to liquefy them, and it was not until more than thirty years later that these substances were condensed.

Andrews, by his classical researches on the critical point of gases and vapours, and especially by his thorough investigation of the behaviour of carbon dioxide when exposed to great pressure at varying temperatures, paved the way for future work on the liquefaction of gases, and showed that great pressure of itself was not sufficient to cause a gas to turn into a liquid, but that a certain limiting temperature must be passed in cooling down the gas before it can by any amount of pressure be liquefied. Thus above this limiting or critical temperature, which is different for each gas, it may be called truly permanent, while below this temperature the gas is liquefiable if only enough pressure is applied to it, and the gas may then be described as a vapour.

When substances evaporate or change from the liquid to the gaseous state, a large amount of heat disappears or becomes latent, and is used up in separating the molecules of the liquid farther apart and giving them increased energy of motion. On account of this disappearance of heat during evaporation great degrees of cold may be produced, and it was by this means that Pictet in 1877 obtained a temperature of $-140°$ Cent., and obtained oxygen in the liquid state. He cooled liquid carbon dioxide by surrounding it with liquid sulphurous acid, kept boiling in a vacuum, and got a still greater degree of cold by then allowing the liquid carbonic acid to evaporate rapidly in an exhausted space. The oxygen was generated in the usual way from potassium chlorate, a salt which splits up and gives off oxygen gas when it is heated; but the gas was produced in a strong iron retort, so that by means of its own pressure alone the gas was compressed by a force several hundred times greater than that of the ordinary pressure of the atmosphere.

The method adopted by M. Pictet is the same in principle as that employed by Faraday. The gas is generated in a closed vessel capable of standing a great pressure, and it is condensed by being simultaneously exposed to great cold and to the pressure of the gas itself, forced to occupy a very small space. In Pictet's original experiment he obtained a temperature of $-130°$ Cent., at which temperature oxygen is liquefied, when the pressure is raised to two hundred and seventy-three atmospheres.

While Pictet was continuing his experiments and endeavouring to liquefy the hitherto permanent gases, the same subject was being investigated by Cailletet, and it was on the same day, the 24th December, 1877, that the French Academy was informed of the success of both these experimenters in liquefying oxygen. Cailletet attained his object by exposing the gas to enormous pressure, produced by means of a hydraulic press, while at the same time the temperature was lowered by suddenly allowing the gas to expand. In this way a sudden disappearance of heat takes place, the heat energy becoming transformed into mechanical motion of the particles of the expanding gas. In Cailletet's apparatus the pressure was produced

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TWO PICTURES OF A FEMALE CHIMPANZEE (*Anthropopithecus troglodytes*) **FROM WEST AFRICA.**

Now in the Gardens of the Zoological Society, Regent's Park. The specimen photographed was purchased by the Society on the 20th April, 1894, and is believed to be about three years old.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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by a steel piston working in a cylinder, the hydraulic cylinder being filled with water. The gas was contained in a capillary glass tube with small bore and thick walls which could support the strong pressure required. The glass tube containing the gas was connected to the hydraulic pump by means of a flexible metallic tube. Cailletet worked with small quantities of gas, while Pictet, by means of his machinery, was able to obtain relatively large quantities of the various liquefied gases.

The results got were only obtained after years of preparation and endeavour by both experimenters, working quite separately and independently. Cailletet made use of the skill and knowledge obtained by him in the prosecution of his business of an ironmaster at his works at Chatillon-sur-Seine; while Raoul Pictet carried on his experiments at Geneva, where he was engaged as a manufacturer of ice-making machinery.

Cailletet's apparatus is singularly simple and effective, and by it he also obtained liquid hydrogen, which appeared as a mist on the inside of his tube when the great pressure to which the gas was subjected was suddenly relieved, and heat thus suddenly absorbed. Hydrogen was thus liquefied into globules of mist on the glass when the pressure of three hundred atmospheres was suddenly removed, while air previously carefully dried changed into a liquid under a pressure two hundred times that of the atmosphere after it was cooled by means of liquid nitrous oxide. This is what happens in Cailletet's experiment: the gas, first of all cooled on account of its quick expansion, descends in temperature below its critical point, and then becomes liquid under the moderate pressure to which it is then exposed. But as expansion and relief of pressure continues, the liquid is soon under too little pressure to remain in this condition, and besides by conduction from surrounding objects heating occurs, so that the liquefied gas soon evaporates and the mist produced is fugitive; this is especially so in the case of hydrogen.

MM. Wroblewski and Olzewski have carried out many experiments, using an apparatus similar to Cailletet's. At − 136° Cent. a pressure of twenty atmospheres sufficed to liquefy oxygen, and the critical temperature of this gas is placed at −112° Cent., that is, it must be cooled *at least* as far as this before liquefaction can take place. The critical temperature of nitrogen is found to be still lower than this, being − 147° Cent., or − 223° Fahr.

On Friday evening, June 26th, 1891, at the Royal Institution, the audience saw liquid oxygen in large quantities freely drawn off from the refrigerating apparatus, and having all the appearance of hot water, with a vaporous cloud above it. In reality the oxygen was boiling at a temperature of − 296° Fahr. — *i.e.*, 328° below freezing point, and the apparent vapour consisted of ice particles produced from the moisture of the surrounding air, cooled from the contact of the chilled gas. On filtering the liquid oxygen, to get rid of the minute particles of solid carbonic acid scattered through it, it was seen to consist of a blue limpid liquid not unlike water. It would naturally be expected that the liquefied gas, when placed in an open vessel in a room at the ordinary pressure and temperature, would with great rapidity, and even violence, hasten to take the gaseous form. But this was not the case; the liquid oxygen evaporated but slowly, and retained its liquid form for a considerable time, although it was only under the usual atmospheric pressure. When a few drops of the liquid were thrown into water, the effect was like that of plunging red-hot iron into a liquid; a fizzling noise was produced, and soon the globules of liquid oxygen were seen each floating about in a little cup of ice formed from the surrounding water. By means of the remarkably cold fluid, alcohol, which remains liquid in even the severest Arctic climate, was quickly frozen into solid lumps; the solidifying temperature for alcohol being −130° Cent.

The effect of cold in rendering sluggish and inert substances which are usually chemically active is strikingly seen in the case of cooled oxygen. At ordinary temperatures oxygen gas has a great affinity for phosphorus, and combines readily with it, producing vigorous combustion with much heat, and light clouds of the solid phosphorus oxide being formed. But a piece of phosphorus when placed in liquid oxygen remains undisturbed; no combination takes place.

By means of liquid oxygen, nitrogen may be liquefied. Advantage is taken of the fact that liquid oxygen, when placed in vacuo, boils at a lower temperature than when under the ordinary pressure. A temperature of 328° Fahr. can thus be obtained, at which both nitrogen and atmospheric air can be liquefied. During the process of liquefaction of air, the two gases of which it is made up become liquid together, but when the temperature is allowed to rise they evaporate separately. The nitrogen, though more difficult to liquefy, comes off as a gas first, leaving almost pure oxygen behind.

Prof. Dewar has also solidified air as well as nitrogen by employing powerful pneumatic apparatus. Pure oxygen has itself never been obtained in the solid form. In order to obtain a succession of lower and lower temperatures, the various liquefied gases are caused to boil in a vacuum. Thus, the more easily liquefiable gases are made use of to abstract heat on their evaporation from those more difficult to liquefy. When these latter are made to boil in vacuo a still lower temperature is attained, and by successive steps a reading on the thermometer as low as —211° Cent. (or —346° Fahr.) has been reached. At these low temperatures experiments of an interesting character have been made on the electrical behaviour of metals, and their electrical resistance has been determined.

On boiling successively in vacuo carbonic acid, nitrous oxide, and ethylene, using the first to take away by their evaporation heat from the gases which are more difficult to liquefy, a temperature of —229° Fahr. is reached, at which oxygen can be liquefied under a pressure of fifteen hundred pounds per square inch. The rapid evaporation of oxygen in vacuo so quickly removes heat from surrounding substances that air and nitrogen are soon liquefied, and these, when treated under powerful air pumps, abstract sufficient heat to allow of the production of solid nitrogen. This last experiment was successfully carried out for the first time in public on January 19th, 1894.

THE MAN-LIKE APES.

By R. LYDEKKER, B.A.Cantab., F.R.S.

THROUGH the generosity of the Board of Governors of the Cheltenham Hospital, the Natural History Branch of the British Museum has been recently enriched by a specimen of great historical interest in the shape of the skeleton of a young chimpanzee from Angola, which was dissected and minutely described so far back as 1699, by Dr. Edward Tyson, in a rare work entitled "Orang-Outang, *sive* Homo Sylvestris," a copy of the volume being appropriately placed alongside of the skeleton in one of the bays on the left side of the great entrance hall. The work in question is the first account of a member of the group of man-like apes having any pretension to scientific accuracy; and the acquisition by the Museum of the skeleton and the volume in which it is described may well serve as the text for a short account of the man-like apes in general.

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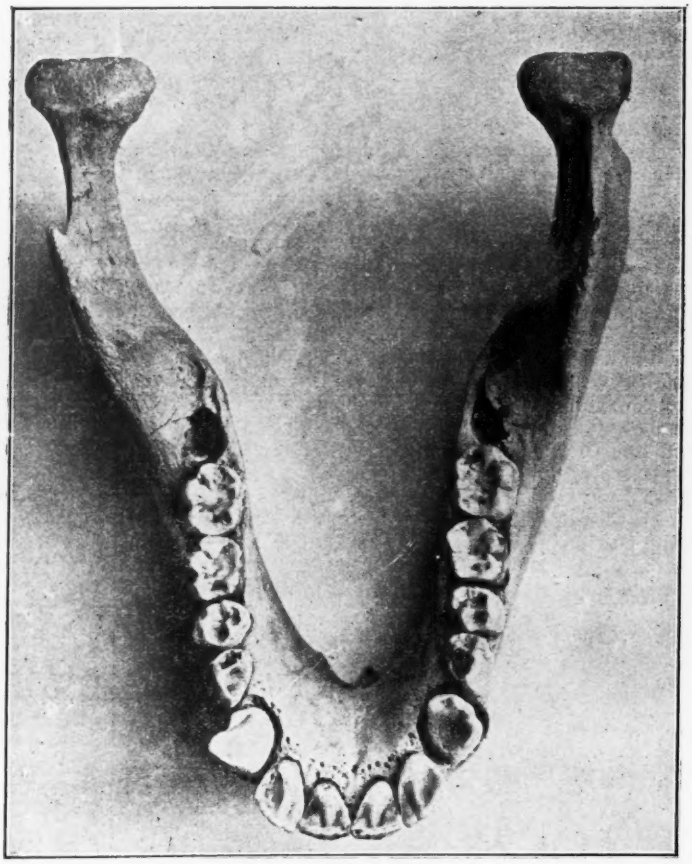
That these apes are our nearest cousins is probably well known to all our readers; but the degree and extent of this relationship, as well as the characters by which it is displayed, are probably far less familiar to many of them. In the first place it will be noticed that we speak of this relationship as one of cousinship, and not of ancestry; and it is well that the reader should at once free himself from any idea that there is any vestige of direct ancestral kinship between these, for the most part, hideous creatures and himself. Such relationship as does exist—and we cannot but believe that such there is—is of a comparatively distant kind; and the common ancestor must have lived ages before the mammoth roamed over the plains and valleys of England, since at that date man was as distinctly differentiated from the apes as he is in the present century. Whether this "missing link" will ever turn up, or in what country it is most likely to have lived, are questions impossible to answer; but from the extreme rarity with which fossil remains of man-like apes are found in countries where they are known to have existed for long ages, and from the probability that the distributional area of the aforesaid "link" was extremely limited, we cannot give much hope that the researches of palæontologists will ever be rewarded by such a "find."

From their large bodily size, coupled with that terrible caricature of the human face and form characterizing the more typical representatives of the man-like apes, no one would have any difficulty in picking out these creatures from among their lower relatives. There might, however, be some hesitation with regard to the long-armed gibbons, a specimen of which is represented in our third full page illustration; and we, therefore, proceed at once to point out how the members of the man-like group may be distinguished as a whole from other monkeys.

We presume, in the first place, that all our readers are aware that apes, monkeys, and lemurs constitute one great mammalian order—the Primates; and likewise that lemurs differ from apes and monkeys by their long fox-like faces and immobile expression, to say nothing of many anatomical peculiarities into the consideration of which it will be unnecessary to enter on this occasion. Possibly we shall be presuming too much as to the extent of their zoological knowledge if we also assume that they are acquainted with the difference between the apes and monkeys of the Old World and the monkeys of the New; and it is accordingly advisable to make this clear at starting. The whole of the Old World representatives of the division of the order to which we are confining our attention are characterized by having teeth agreeing both in number and arrangement with those of man. Thus in all cases in each jaw there are two pairs of incisors, a single pair of eye-teeth, tusks, or canines, and five pairs of cheek-teeth, of which the last, or "wisdom-tooth," is frequently very late in making its appearance, as shown in the accompanying figure of the lower jaw of an immature chimpanzee, in which it is still imbedded in a cavity in the bone, the top of which is open. It is further essential to observe that of these five cheek-teeth the first two on each side are simpler than the three hinder ones, and are preceded in the infant by milk-teeth, whereas the latter have no such predecessors. It is accordingly the custom to call the two simpler teeth premolars or bicuspids, and the three more complex ones molars. If now, we examine an ordinary American monkey, we shall find six cheek-teeth



Lower jaw of an immature Chimpanzee, with the "wisdom-tooth" still concealed in its socket.

on each side of both the upper and lower jaws, of which half are premolars and half molars, while in the marmosets, which constitute a second American family, although the total number of cheek-teeth is the same as in the Old World forms, yet the proportion is different, there being three premolars and two molars. It may, therefore, be concisely stated that all American monkeys differ from their Old World cousins in having three instead of two pairs of premolar teeth, whence it may be inferred that they belong to a lower and more generalized type, there being a universal tendency throughout the higher vertebrates to a diminution, or disappearance of the teeth with the advance of specialization. In the marmosets the loss of the last molar is unique in the higher division of the order, and is indeed a somewhat remarkable peculiarity to occur in a herbivorous mammal, among which the reduction is usually confined to the front and premolar teeth.

As the teeth serve most readily to differentiate the Old World monkeys from their American allies, so the man-like apes are sharply distinguished from their relatives by the conformation of these organs. As shown in the accompanying figure of the lower jaw of the chimpanzee, the molar teeth of the man-like apes closely resemble our

ONE OF THE GIBBONS, OR SMALLER MAN-LIKE APES.

From a Specimen in the Zoological Society's Gardens.

The extreme length of the arms, characteristic of the genus, is well displayed, while this species also shows the white ring round the face distinctive of some Gibbons.

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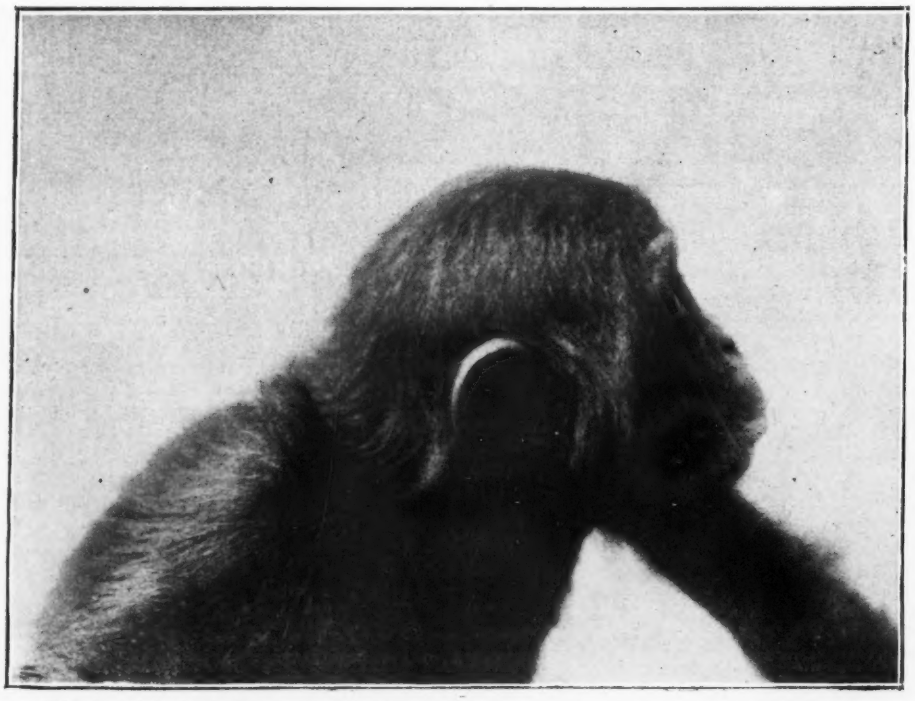
own, having the angles of their crowns rounded off, and carrying on their grinding-surfaces four very blunt tubercles, placed alternately to one another, as well as a somewhat smaller tubercle at the hinder end. On the other hand, in the monkeys the molar teeth are oblong in form, and carry four very prominent tubercles arranged in pairs at the two extremities of each, and each pair being connected so as to form a couple of more or less well-defined transverse ridges extending right across the crown. Then, again, whereas in the man-like apes the last molar, or "wisdom-tooth," in the lower jaw is similar in form to the two teeth in front of it, in the great majority of the Old World monkeys this tooth has a large projecting heel at its hinder end. These dental characters afford very important evidence of the close kinship of the man-like apes to man himself, and undoubtedly outweigh the difference in the form of the whole dental series now to be noticed, which is largely due to adaptation. In both the upper and lower jaws of man, the teeth, as we all know, are arranged in a regular horse-shoe series, with scarcely any interruption to the continuity by the tusks, which are but little taller than the other members of the series. In the adults (and especially the males of the larger species) of the man-like apes the cheek-teeth are arranged in a nearly straight line, and form a more or less angulated junction with the line of the incisors; the large tusks occupying the angle between the two series, and thus forming a marked break in continuity. In these respects the man-like apes resemble their inferior kindred. If, however, we take a young individual of the larger anthropoids, and especially the chimpanzee, it will be found (as shown in our illustration) that the teeth, owing partly to the imperfect protrusion of the tusks, form a much less interrupted and more regularly curved series. Indeed, with the exception that the whole jaw is longer and narrower, and the partially protruded tusks are proportionately larger, the characters of the figured specimen make a very marked approximation to the human type; and the jaw of a chimpanzee at this stage may be regarded as almost intermediate in structure between that of man and that of an adult male gorilla. Moreover, in this juvenile state the bony union of the two branches of the lower jaw partakes of the short and rounded form characterizing that of man; whereas in the adult it becomes longer and more deeply channelled, like that of the lower monkeys. In many respects the teeth and jaws of the gibbons, or smallest representatives of the group under consideration, conform to the intermediate type. Not only are the human characteristics most developed in the teeth and jaws of the young of the larger man-like apes and the gibbons at all ages, but the same is true with regard to the skull of the former. The skull of the young gorilla, for instance, lacks the beetling crests over the eyes and the prominent ridge down the middle of the crown which give such a forbidding and repulsive aspect to the cranium of the full-grown male. This loss of human resemblances is due to specialization taking two different lines in man on the one hand, and in the larger man-like apes on the other; the development in the one case tending to increased size of brain, coupled with no marked increase in the size of the tusks, while in the other the brain grows at a less rapid rate, and the skull and tusks (more especially in the male) assume characters approximating them to those of the inferior animals. Both in men and apes the young condition may accordingly be regarded as the most generalized.



Side view of the head of "Jenny," the Chimpanzee, in the Zoological Gardens. From a photograph by Mr. Ranyard.

Among the other features in which the man-like apes differ from monkeys and resemble man, are the absence of dilatable pouches in the cheeks for the storage of food, and the total loss of the tail, as well as the flattened, instead of laterally compressed, form of the breast-bone; the gibbons alone retaining the naked patches on the buttocks so characteristic of the monkeys, but only in a much reduced condition. The gorilla and chimpanzees further differ from the other members of the group, and thereby resemble man alone, in the loss of the so-called central bone of the wrist—a bone occupying a nearly central position between the upper and lower rows of small bones of which that joint is composed. What may be the object of the disappearance of this bone, it is not easy to say; but the fact that it is wanting in the two genera of apes just mentioned is very significant of their close structural

affinity with man. In one respect the man-like apes stand apart both from the human and the monkey type, namely, in the great relative length of the arms as compared with the legs, the disproportion being most strongly marked in the gibbons, which are actually able to walk in the upright posture with their bent knuckles touching the ground.

So far, indeed, as their bodily structure is concerned, the man-like apes seem undoubtedly more nearly related to man than they are to the lower monkeys; and they constitute a family (*Simiidæ*) by themselves, which may be regarded as intermediate between the one (*Cercopithecidæ*), including the lower monkeys, and that represented by man himself. While at present, as we have said, the "missing link" between man and the apes is wanting, extinct forms tend to connect the latter very closely with the monkeys. For instance, a fossil ape (*Dryopithecus*) from the Miocene Tertiary strata of France has the bony union between the two branches of the lower jaw much longer than in any existing man-like ape, although it is approached in this respect by the gorilla; while from the corresponding beds of Italy another extinct form (*Oreopithecus*) appears to be in great part intermediate between the man-like apes and the lower monkeys. It may be mentioned here that in the same strata in which occur the remains of the dryopithecus are found flint flakes which have been regarded as exhibiting signs of artificial chipping, and the extinct ape in question has consequently been credited with the production of these supposed weapons. Although we have not seen these wonderful flints, we confess ourselves to be as sceptical in regard to their reputed manufacture as we are with respect to Prof. Garnier's ability to understand "ape-language."

The present distribution of the anthropoid apes clearly points to the existing species being the last survivors of a group which was once widely spread over the Old World, when warmer climatic conditions prevailed over what we now call the temperate regions. The gorilla, for instance, is confined to western equatorial Africa, where it is accompanied by the two species of chimpanzee, one of which ranges eastwards across the continent as far as Uganda.

The orangs, of which there are probably two species, on the other hand, are confined to the great islands of Sumatra and Borneo; while the numerous species of gibbons have a wide range in south-eastern Asia, attaining their maximum development in the Malayan Archipelago and the adjacent regions. This distribution is remarkably discontinuous, but the little that we at present know of the past history of the group tends somewhat to consolidate the scattered distributional areas of the group. One of the most noteworthy of such palæontological discoveries is the fact that a chimpanzee once inhabited northern India; while it is most probable that an orang also was a contemporaneous dweller in the same country. This suggests that India may have been the original home of the larger man-like apes; from whence the chimpanzees and gorillas migrated south-westwards to equatorial Africa, while the orangs travelled in an easterly direction to find a last home in the tropical islands to which they are now confined. This probability, that India was the home of the larger members of the group during the later Pliocene period, further suggests that it is on that country we should concentrate our hopes of discovering the "missing link"; and it is not a little noteworthy that, so far as the very fragmentary specimen by which alone it is known admits of our forming a judgment, the Indian extinct chimpanzee appears to have approached nearer to the human type than do its living cousins. During the earlier Miocene epoch, as we have seen, an extinct genus of large man-like apes inhabited western Europe, which, during the commencement of the Pliocene period, was likewise the home of a species of gibbon.

Of the four existing genera of the man-like apes, the chimpanzees (*Anthropopithecus*) are clearly those which come nearest to man, this being especially shown by the shortness of the bony union between the two branches of the lower jaw, the form and mode of arrangement of the teeth (especially in the young), the relatively small development of the tusks of the male, the absence of the enormous bony crests on the skull so characteristic of the gorilla, and the slight difference in the size of the two sexes. The specimen shown in Mr. Ranyard's photographs is a female recently acquired by the Zoological Society, whose amiable disposition and general intelligence promise to make her almost as popular as the deceased "Sally."

The chimpanzees and the gorilla alone resemble man in having seventeen vertebræ between the neck and the sacrum, and likewise in the absence of the central bone in the wrist, although they differ in the comparatively unimportant feature of possessing an additional pair of ribs. In addition to the characters already mentioned, the gorilla (*Gorilla*) differs from the chimpanzee in the more oval contour of its brain, thereby approximating more nearly to the human type.

The reduction of the number of vertebræ between the neck and the sacrum to sixteen, together with the retention of the central bone in the wrist, the great length of the arms, which in the upright posture reach to the ankles, and the peculiar upward prolongation of the vertex of the skull, serve at once to show that the orangs (*Simia*) stand on a lower evolutionary platform than either of the preceding representatives of the family. Externally they are further distinguished by the rudimentary condition of the great toe, the peculiarly flattened form of the almost disc-like leaden-hued face of the adult, and the red tinge of the long and shaggy hair, the latter being in marked contrast to the black hue of the gorilla and chimpanzees. Although in possessing only a dozen pairs of ribs the orangs differ from both the latter and resemble man, yet this resemblance is greatly outweighed by the difference in the number of the vertebræ.

Agreeing with the orangs and the lower monkeys in the presence of a central bone in the wrist, the gibbons (*Hylobates*) make a further approximation to the latter in the retention of small naked callosities on the buttocks; while they are likewise distinguished by their small size, and the inordinate length of their arms, which, as already said, admit of the bent wrist being applied to the ground when the animals are walking in the upright posture. Another characteristic of the gibbons is the smooth contour and relatively large size of the brain-case of the skull, which gives them a more human-like physiognomy than the adults of their larger relatives; this does not, however, by any means imply that the brain-power of these creatures is greater, but is merely due to the circumstance that in any group of animals the relative size of the brain is necessarily larger in the smaller forms. In colour, gibbons are subject to considerable variation, the Hainan species being uniformly black, Müller's gibbon brownish-black and grey, with a whitish circle round the face; while the silver gibbon takes its name from the uniformly silver-grey hue of its pelage. Gibbons are the only apes which habitually walk in the upright position, and although they frequently aid themselves by applying the hands to the ground, they often while walking clasp them together at the back of the head. In addition to this peculiarity, these creatures are remarkable for the extreme agility of their movements, and their loud

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unearthly cries, which resound morning and evening through the forests frequented by these animals, and in imitation of which the hoolock of Assam and Burma takes its name. Although the confined limits of a cage in the Zoological Gardens are far from favourable for displaying the marvellous rapidity of the movements of these creatures—so rapid indeed that birds on the wing are not unfrequently captured—yet the specimen which has been photographed so excellently by Mr. Ranyard indulges in the most frolicsome antics among the ropes and branches placed in its cage, to the manifest delight of all spectators. Equally well marked is the delicacy of touch possessed by the gibbons: this being shown when they amuse themselves by playing with spiders, which they allow to descend by spinning a thread attached to a finger, and then suddenly jerking them back into their hands, when the unfortunate performers are devoured with much apparent gusto.

THE DEFINING POWER OF INSECTS' EYES.

By A. C. Ranyard.

THE exquisite minute details which the microscope so frequently reveals to us, on examining insects and the minute objects by which they are habitually surrounded, might lead one to suppose that insects can see and appreciate much smaller things than are visible to the eye of man; but though we know very little as to what range of sounds insects can hear, or as to their sense of smell, and the other senses they possess, we are able to assert pretty confidently that the defining power of the composite eye of an insect is very inferior to the defining power of the human eye.

A man with keen eyesight can just distinguish as separate objects adjacent lines or dots which are separated by an interspace that subtends about a minute of arc. The reader may easily try the experiment for himself. The lines in the shaded area in Fig. 1 are separated by intervals of about a millimetre from the centre of one line to the centre of the next. Seen from the distance of a foot or fifteen inches, at which he is reading this page, the lines are easily perceived as separate rulings, but from the other side of the room the shading in Fig. 1 appears of a uniform grey tint. At a distance of three thousand four hundred and thirty-eight millimetres, or about eleven feet, a millimetre subtends an angle of one minute. With a suitable light a keen-sighted person will just distinguish the separate lines at a distance of about eleven feet. I can only distinguish them as separate lines at a distance of about six feet. Hence for a keen-sighted person, in order that two objects may be seen as two, they must subtend at least an angle of about one minute at the eye. For objects which are not suitably illuminated, or for faint stars, a still greater angular distance is necessary in order that we may see them as distinct and separate objects. Thus in ϵ Lyræ, the quadruple star near Wega, the two pairs are separated by a distance of about three minutes twenty-seven seconds, but I only see them as an elongated pair; and I gather from experiments I have tried with children and elder friends that very few people see the two pairs as separate stars, though most long-sighted people see them as an elongated disc, and are able to point out with certainty the direction in which the disc is most elongated.

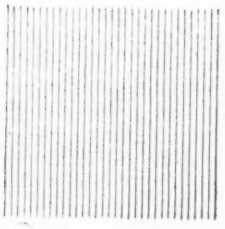


Fig. 1.—Lines about a millimetre apart.

There is more than one reason why the limit of distinct vision for the human eye corresponds to about one minute of arc. The retina is a sort of tessellated pavement made up of small organs known as rods and cones, and the spot in the retina which we use when we fix our attention on the examination of an object is termed the *fovea lutea*. In the *fovea* there are only cones packed closely together and separated by intervals of about four millionths of a metre, or about half the diameter of the red corpuscles. The optical centre of the eye lies at a distance of about a centimetre and a half in front of this part of the retina, and at this distance four millionths of a metre, or the distance between the centres of adjacent cones, subtends an angle which is just a little less than one minute; hence, in order that the images of two points of light may fall on the corresponding parts of adjacent cones, their distance apart must subtend an angle of about one minute as seen from the optical centre of the eye.

There are other reasons, however, why the human eye cannot perceive objects as separate objects when they are separated by intervals of less than one minute. As has been pointed out by Mr. Johnstone Stoney in a very interesting paper published by him in the *Scientific Proceedings of the Royal Dublin Society* of 20th December, 1893,* the interference due to the small diameter of the pupil of the eye causes the image of a point to be represented by a patch or spurious diffraction disc which fixes the *minimum visibile* corresponding to the diameter of the pupil.

Thus the angular diameter of the first dark ring seen about the image of a star in a telescope, estimated from the middle of the object-lens, is $\theta = (1{\cdot}22)\ \frac{\lambda}{A}$, where λ is the wave-length of the light, and A the aperture or diameter of the object-lens. If in this formula we put $\theta = 1' = {\cdot}00029$ in circular measure, and $\lambda = {\cdot}6$ of a millionth of a metre (which is the wave-length for yellow light), we have

$$\cdot00029 = (1{\cdot}22)\ \frac{\cdot6}{A},$$

which gives A = 2524 millionths of a metre, or very nearly one-tenth of an inch, as the diameter of the pupil of the eye, which would give rise to a spurious disc of one minute in angular diameter; and when we scrutinize well-illuminated objects, one-tenth of an inch is about the

Fig. 2.—Micro-photograph of the lenses of the compound eye of a Water Beetle.

* "On the Limits of Vision: with special Reference to the Vision of Insects," by G. Johnstone Stoney, M.A., D.Sc., F.R.S., Vice-President Royal Dublin Society (republished in the *Philosophical Magazine* for March, 1894.)

diameter to which the pupil of the eye shrinks. Again, the human eye, viewed as an optical instrument, is far from perfect. It is not corrected for chromatic defect or spherical aberration, and such optical imperfections affect the sharpness of the image thrown upon the retina, and if the texture of the retina were finer, and the diameter of the pupil larger, they would alone fix the limit of the *minimum visibile* for human vision at not far from one minute.

In the composite eyes of insects the retina is convex, with a number of separate small lenses in front of it,

FIG. 3.—Reproduced from a photograph of a carte-de-visite, taken through the lenses of the multiple eye of a Water Beetle.

while in the eyes of vertebrates the retina is concave, with one lens which serves for the whole retina. At last year's meeting of the British Association at Nottingham, the president mentioned in his opening address that the image formed by the compound eye of an insect had been photographed.

By the kindness of Dr. Spitta I am able to exhibit such a photograph to the readers of KNOWLEDGE. Fig. 2 is the micro-photograph of a part of the compound eye of a water beetle (*Dysticus marginales*), showing the lenses slightly pressed between a microscope slide and a thin cover, so that each of the little lenses is slightly flattened or depressed at its centre, and Fig. 3 shows the multiple image of a photograph as seen through the above mosaic of hexagonal lenses.

By the kindness of Mr. Gerard Smith, M.R.C.S., I am also enabled to reproduce, for the benefit of our readers, a micro-photograph of the section of the eye of a large fly (*Erystalis tenax*), Fig. 4, which Mr. Smith has very beautifully mounted and photographed. In describing the photograph, Mr. Smith says the little lenses of the cornea can be made out on the surface with a few protective hairs; each facet forms the base of a tiny cone—the points or apices of all these cones are towards the interior of the eye; each cone is lined with pigment in such a way that only a microscopic passage is left clear in the centre, through which a ray of light can penetrate and affect the single nerve which enters the apex of each case. Fig. 5 is a more enlarged photograph, also made by Mr. Gerard Smith, of a portion of the same section, and in it the arrangement of nucleated nerve cells can be seen forming a stratum around the lower ends of the cones. Around each nerve which passes into the apex of a cone there is a group of three large nerve cells, the central one being apparently on the main nerve, and the two outer ones apparently attached by short fibres to the nervous filament along which the optical impression is carried to the brain of the insect.

Fig. 4 shows in a very diagrammatic form the section of a compound eye, with the lenses, which throw minute images of the objects opposite to them on to the blackened sides of the conical tubes behind them; a nerve filament leads into the apex of the cone, and carries the optical impression perceived to the insect's brain.

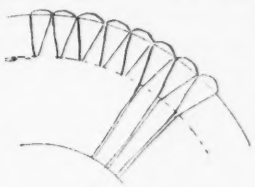


FIG. 4.

The simplest form of composite eye would be a spherical shell perforated with a number of small radial holes. If a sensitive paper were placed in contact with the inner surface of the shell, it would be impressed with a confused picture of surrounding objects, for the light which reaches the bottom of any hole would be derived from objects situated immediately in front of the hole, and the smaller and deeper the holes the less confused would be the mosaic picture imprinted upon the sensitive paper. Mr. A. Mallock, in an interesting paper recently communicated to the Royal Society, and printed in the February number of the Royal Society's "Proceedings,"* has shown that a spherical composite eye without lenses would need to have a diameter of some sixty-nine feet in order to have a defining power equivalent to that of the human eye, for he shows that the diameter of the holes in the shell should not be less than two thousand wave-lengths of light—say one twenty-fifth of an inch—or diffraction would materially interfere with the result; and in order to give a defining power of one minute the thickness of the shell would need to be seven thousand times one twenty-

FIG. 5.—Micro-photograph of a thin vertical section made through the eye of a large Fly.

fifth of an inch, or twenty-three feet. The radius of the sensitive sphere within the shell is determined by the condition that, if the picture is to be continuous, the adjacent

* "Insect Sight and the Defining Power of Composite Eyes," by A. Mallock. Communicated by Lord Rayleigh, Secretary of the Royal Society.

holes must just be in contact at the internal surface of the shell; that is to say, the diameter of the hole must subtend one minute at the centre of the spherical shell, or the sensitive surface must have a radius of eleven feet six inches.

If, still keeping one minute as the limit of definition, we substitute the arrangement actually found in composite eyes, and in place of the long tunnels in a thick shell we use short tunnels or cones with a lens at the outer end of each, and a diaphragm at the inner end, pierced with a small central hole, the proportions of the eye will be determined in the first place by the diameter of the lens which will just define one minute, and secondly, by making that diameter subtend one minute at the centre of the sphere.

The size of the image of a point formed by a lens (as seen from the optic centre of the lens) is inversely as the diameter of the lens, and it takes a lens four inches in diameter to define one second of arc, *i.e.*, to separate points

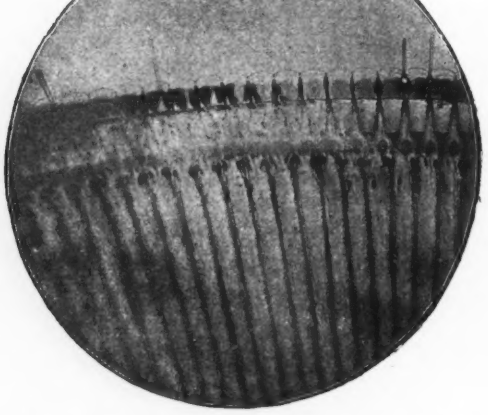


FIG. 6.—Micro-photograph made with a high power of vertical section through the eye of a Fly.

one second apart; hence the lens which will just define one minute is $\frac{4}{60}$, or 0·066 of an inch in diameter, and the radius at which 0·066 of an inch subtends one minute is about nineteen feet. Mr. Mallock therefore concludes that no composite eye of practicable dimensions, acting as supposed above, could be made to give definition even approaching that of the human eye.

The great advantage of the composite eye to insects lies in the fact that the closer they are to an object the better will be their sight of it, for the greater will be the number of lenses employed to produce the impression; whereas in the simple eye, the greater focal length of the lens inconveniently limits the distance at which a distinct view can be obtained. Insects evidently see all distant objects in a very diffused and badly defined manner. The impression perceived must be something like a picture executed in very coarse wool-work—or very rough mosaic—near and distant objects being equally in focus; and it is only when an object is brought close to the eye, so that it covers an area corresponding to several facets of the eye, that its outline would be defined. Mr. Mallock has measured the diameters of the facets and of the composite eyes of many insects, and gives the following interesting table indicating the probable defining power of their vision. It will be seen that the blow-fly and the dragon-fly are keen-sighted as compared with the bees and butterflies.

Species.	Length of body.	Greatest dimension of eye.	Diameter of aperture of ommatidium.	Angle between axes of adjacent ommatidia in minutes.	Defining power of lens of diameter d in minutes.
	Inches.	Inches.	d.	θ	$\times$
Diptera—					
1. Fly like a bee, *Eristalis*	0·60	0·108	0·0012	56	55
2. Fly like a wasp, *Sericomyia* ...	0·70	0·12	0·0016	48	71
3. Blow-fly, *Lucilla*	0·34	0·07	0·0018	84	35
4. Very small flies, species not identified	0·20	0·026	0·00076	126	87
5. Ditto	0·13	0·021	0·0005	105	113
Hymenoptera—					
6. Hornet	1·0	0·152	0·0014	53	48
7. Wasp	0·7	0·088	0·0011	84	60
8. Bee	0·6	0·100	0·00072	50	90
9. *Chrys's*, scarlet and blue	0·4	0·045	0·00094	105	70
Lepidoptera—					
10. Small cabbage, white	0·8	0·059	0·00072	86	90
11. Red admiral ...	1·0	0·072	0·00095	76	69
12. Small copper ...	0·5	0·050	0·00071	100	93
13. Yellow underwing	0·75	0·064	0·00092	70	72
14. *Noctera* ...	0·7	0·060	0·00090	70	74
Dragon flies—					
15. Large dragon fly, *Æschna cyanea*	3·5	0·282	large lenses 0·0023 small lenses 0·0016	48	41
16. *Libellula Striolata*	2·5	0·191	large lenses 0·0027 small lenses 0·0015	50	45
17. Green grasshopper	1·1	0·057	0·0011	80	60
18. *Tipula*	1·0	0·027	0·00095	200	70

Notices of Books.

The Fauna of the Deep Sea. By Sydney J. Hickson, M.A. Cantab. et Oxon., D.Sc. London. (Kegan Paul, Trench, Trübner & Co., 1894.) Dr. Hickson remarks that the bottom of the deep sea was, until recently, quite an unknown region. It was regarded by most persons, when it entered into their minds to consider it at all, as one of those regions about which we do not know anything, never shall know anything, and do not want to know anything; but during the last quarter of a century the English, French, German, Italian, Norwegian and American Governments have vied with one another in despatching expeditions, well equipped for exploring the dark regions beneath the sea, and a vast store of information is to be found in the scientific reports of these expeditions which have been issued. Dr. Hickson's book brings together, in a small compass and in a very interesting form, many of the more important conclusions which have been arrived at, as well as the facts on which these conclusions are based, and the whole is presented in a form which will be readily understood by those who do not possess a specialist's knowledge of genera and species.

The deep sea seems to be absolutely dark, so far as sunlight is concerned. The temperature is only a few degrees above the freezing point, and the pressure is enormous. There is little or no movement of the water. The bottom is composed of a uniform soft mud, and there is no plant life.

Dr. Hickson thinks that the darkness of the deep sea is probably relieved by the brilliant phosphorescence of many of the deep sea fish. If, he says, we may be allowed to compare the light of abysmal animals with that of surface forms, it is possible that some regions of the deep sea may be as brightly illuminated as a European street is at night—an illumination with many bright centres and many dark shadows, but quite sufficient for a vertebrate eye to distinguish readily, and at a considerable distance, form and colour.

To give an example of the extent to which the illumination due to phosphorescent organisms may reach, he quotes Sir Wyville Thomson as stating "that on leaving the Cape Verde Islands the sea was a perfect blaze of phosphorescence. There was no moon, and although the night was perfectly clear and the stars shone brightly, the lustre of the heavens was fairly eclipsed by that of the sea. It was easy to read the smallest print, sitting in the after port in my cabin, the bows shed on either side rapidly widening wedges of radiance, so vivid as to throw the sails and rigging into distinct lights and shadows." All the abysmal creatures have eyes, and the deep sea crustacea are uniformly coloured red, though the sun's light does not give any perceptible illumination at a depth of even two hundred fathoms. MM. Fol and Sarasin, experimenting with very sensitive bromo-gelatine plates, found that there was no reaction after ten minutes' exposure at a depth of four hundred metres on a sunny day in March.

At a depth of two thousand five hundred fathoms the pressure is, roughly speaking, two and a half tons per square inch—that is to say, several times greater than the pressure exerted by the steam upon the pistons of our most powerful engines. Every animal at the bottom of the Atlantic Ocean lives under a pressure about twenty-five times greater than will drive a railway train. What this enormous pressure is may be realized by the fact that thick glass tubes, filled with air and sealed up at either end, are crushed to powder by the water pressure before they reach a depth of two thousand fathoms.

Though Dr. Hickson's book contains an immense amount of accurate information, it is comparatively light reading, and may be confidently recommended.

Practical Photo-Micrography. By Andrew Pringle, F.R.M.S., &c. (Iliffe and Son. London, 1894.)—Mr. Pringle's book gives valuable practical instruction in methods of research which are every day becoming more and more important to biological students, as well as to doctors and men of science generally. It does not profess to give any history of micro-photography, or to treat theoretically of the optical and photographic matters dealt with, but the practical hints and suggestions to be found on nearly every page will be welcomed by those who wish to retain photographic records of the researches they are engaged upon.

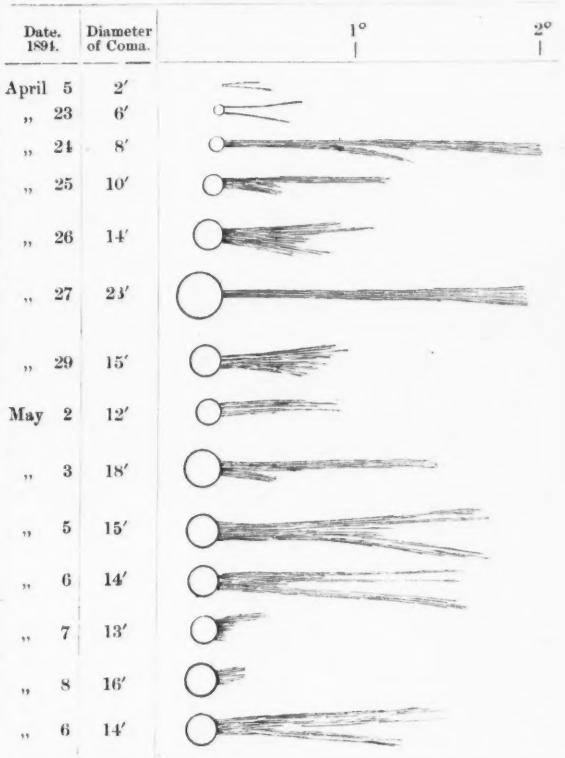
ON THE CHANGES OF FORM IN COMETS' TAILS.

By A. C. RANYARD.

EVIDENCE is very rapidly accumulating which tends to show that the matter of a comet's tail is (at all events in the case of small comets) driven away from the nucleus in a very irregular and spasmodic manner, indicating that the action going on in the nucleus as the comet approaches the sun is by no means quiescent and regular, but rather corresponds in spasmodic irregularity with the outbursts which accompany the rapid boiling of a liquid. There seems to be a capricious irregularity about the explosive phenomena we are familiar with in the action of terrestrial volcanoes and also in the solar chromosphere; possibly such irregularities are always observable when a rapid change of physical condition is going on.

Mr. H. C. Russell, the Director of the Sydney Observatory, has kindly sent me some photographs he has taken of the Comet "Gale," with the accompanying series of drawings showing the remarkable manner in which the tail of the comet appeared to him to vary in length and brightness from day to day. The presence or absence of moonlight or hazy weather might have given rise to slight differences in the apparent length of the tail, though none actually existed, but it will not be contended that the great changes shown in this series of drawings can be accounted for in any such simple manner.

Rough Sketches of the Tail of Comet "Gale." April—May, 1894.



Mr. Russell carefully estimated the diameter of the head of this comet on each occasion, and found the great and irregular variations indicated in his diagrams. If we could be sure that the nebulous and apparently spherical envelope about the nucleus was gaseous, and that it was held in equilibrium by the attraction of the nucleus, we should have at our disposal a very satisfactory means of estimating the mass of the comet, or rather of making a minimum estimate of its mass; for the envelope, if apparently spherical, could not have approached the neutral point between the sun and the comet, where the attraction of the sun and the cometary nucleus counterbalance one another. A gaseous envelope about the nucleus held in equilibrium by attraction, and extending to a height equal to half the distance between the nucleus and the neutral point would, if viewed from the direction in which we were viewing Gale's comet, have appeared distinctly elliptical;

but if the nebulous envelope was composed of a fog of solid particles, each acted upon by repulsive forces from the nucleus as well as by a repulsion from the sun, this test for comparing the mass of the comet with the mass of the sun fails us. Although we know from observation that incandescent gaseous matter generally exists round the head of a comet, we have no evidence that the gaseous matter forms an atmospheric envelope in equilibrium under gravity; indeed, it seems probable, from polariscopic observations, that a great part of the nebulous light is due to solar light dispersed by small particles.

Through the kindness of Mr. J. N. Cobb, of Philadelphia, I have obtained from Mr. Alfred Rordame, of Salt Lake City, Utah, a beautiful photograph of Rordame's comet, taken on the 13th July. Its very rapid motion amongst the stars is evidenced by the long trails they have left on the plate while the camera was kept following the comet in its motion amongst the stars. It will be seen that, as in the photograph of Brooks' comet, reproduced in the May number, the photograph of Rordame's comet affords ample evidence that the matter of the tail was driven away in clouds of varying density, and that these clouds have a structure which suggests an analogy with solar prominence forms, and seems to indicate that the outrushing material has suffered resistance in passing through a resisting medium.

That these rapid changes of form and cloud-like masses in comets' tails have only recently been noted seems to point to the conclusion that the intermittent character of the outflow of matter along the tail is more marked in small comets than in the larger comets with which we were previously familiar. It may be that the feeble gravity that holds together the group of meteoric stones which probably forms the nucleus of a comet, permits the form of the group to be more easily disturbed by the ebullition of vapour in the case of a small group than in the case of a large group.

Thus, in the case of a small comet, fresh meteors would continually be brought to the outer part of the swarm, where they can be more freely acted upon by the sun's radiation, and with a given evolution of vapour these changes would take place more rapidly in a small than in a large group of stones, where the gravitating forces between the various stones of the swarm are larger compared with the gaseous repulsion due to the vapour evolved; and in the case of a small comet, the changes of form within the nucleus would probably be greater, and the evolution of vapour more irregular, with a given rise of temperature than in the case of a large comet.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Sir,—In a letter in your May number (p. 116) Mr. Skene states that he observed the zodiacal light "in daylight, *i.e.*, immediately after sunset, of a pretty rose colour," but I would venture to suggest that it is quite impossible that what he saw really was the zodiacal light at all. Even in the tropics the zodiacal light is never visible till at least half an hour after sunset, and even then it can be seen only with difficulty. The mention of the "rose-colour" suggests the probability that what was really seen was a crepuscular ray, which would answer very well to the description given. During nearly twenty years of careful observation of the zodiacal light I have never been able to distinguish any trace of colour in it. My observations, indeed, have been almost entirely made within the tropics, where the light makes a large angle with the horizon, but this is the most favourable condition for seeing it in its true form and colour.

I would like to add that, whether or not there is any connection between the intensity of the zodiacal light and the sunspot cycle, there can be no doubt that during the past three years the light has been more brilliant than during several preceding years. At present the light is very strong, and one and a half hours after sunset it can easily be traced through an arc of from 60° to 70° from the horizon.

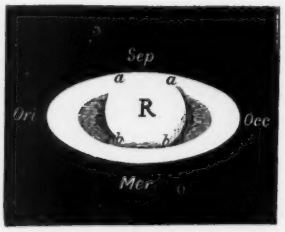
Yours truly,

The Observatory, Madras, 30th May, 1894. C. Michie Smith.

SATURN'S DARK RING.

To the Editor of Knowledge.

Sir,—When, at the end of 1850, the now familiar "crape ring" of Saturn was practically simultaneously discovered in America by Prof. Bond, of Cambridge, U.S., and in this country by Dawes, the question at once arose as to whether this was, so to speak, a recent addition to or development of the Saturnian ring system, or whether it had merely escaped the attention of earlier observers. When this question was first mooted, it was speedily remembered that in the year 1838 Galle, in examining Saturn, at Berlin, had noticed a perceptible shading off on the inner edge of the interior bright ring, and that Encke had, in fact, published a description of this observation, to which at the time but scant attention would seem to have been paid, possibly owing to the somewhat vague language in which it was couched. Nay, ten years previously, the dusky ring would seem to have been perceived by the observers in Rome, who, however, apparently did not consider the phenomenon worthy of record, or, at all events, of publication. Beyond this, in the outset, no one attempted to go, and the advocates of the recent evolution of this strange appendage of the planet entrenched themselves behind the authority of Sir William Herschel, who, in his innumerable observations of Saturn, *must*, they contended, have seen it at one time or another had it been then existent, or, at all events, as visible as it subsequently became. Further research, however, once more showed how utterly fallacious merely negative evidence may prove, for Chambers, in his *Descriptive Astronomy*, speaks of a passage in the *Philosophical Transactions* for 1723 which "almost leads one to infer that he (Hadley) had seen the dusky ring, though without being able to make up his mind what it was." Moreover, we find Hind thus expressing himself on page 32 of Vol. XV. of the Royal Astronomical Society's *Monthly Notices*, in connection with this question: "I have found among Picard's observations on the ring, in the same work, a notice of that second dark belt, traversing the globe at the interior edge of the rings, which, with every appearance of probability, has been identified with the obscure ring of modern observers. M. Otto Struve alludes to observations of this nature made early in the eighteenth century; but probably Picard's had escaped his notice. . . . We have, therefore, reason to suspect the existence of the obscure ring, at least as far back as 1673, notwithstanding the negative evidence which the subsequent observations of Sir W. Herschel and others may be considered to afford."



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COMET b 1893 (RORDAME).

From a Photograph taken July 13th—9h. 10m. to 10h. 20m.

Direct Photo Engraving Co., 9, Barnsbury Park, N.

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But a recent attempt has been made by Mr. H. T. Vivian, F.R.A.S., to carry this discovery still further back, and to attribute it to Dr. Robert Hooke, the famous first Curator of the Royal Society, an observation of whose he quotes in the columns of one of your contemporaries, illustrating it with what purports to be an accurate copy of the original engraving in the *Philosophical Transactions* for 1666. Now this is a point of such curious historical interest that I have taken the pains to inspect the original engraving, which, I am bound to say, I do not find to bear out Mr. Vivian's contention. Through the kindness of my friend Mr. C. Leeson Prince, F.R.A.S., who has taken a photograph from the plate in the *Philosophical Transactions*, I am enabled to give an accurate reproduction of it here. Should it be rendered in these columns with the exactness which usually distinguishes your beautiful protographic illustrations, I think that the following facts will become evident to the careful observer:—In the first place, the lines representing shading between ring B and the body of the planet will be seen to be carried uniformly across that interval, and the apparent darkness in actual contiguity with the globe of Saturn to have had its origin in the printing. But, furthermore, if we are to accept this seeming difference of tint within the ansæ as an attempted delineation of the actual dark ring, what interpretation are we to put upon the perfectly apparent, carefully engraved, and cross-hatched dark lune *outside of the following ansa?* Did—or did not—Hooke see an exterior dark ring in this portion (and nothing whatever outside of the western ansa) or what? Surely no unprejudiced observer, approaching the consideration of this question without prepossession, will deny that this strange feature is much more definitely shown than is that which Mr. Vivian imagines to represent ring C. William Noble.

To the Editor of Knowledge.

Sir,—In your note to my letter published in the May number, you ask how I can distinguish between the effects of the different concurrent circumstances which accompany "changes of air." This is only to be done by making use for observation of chance occasions when the usual "concurrent circumstances" are absent, and of those occasions when the effects of similar circumstances without changes of air may be observed. The following is an unusually plain example of what I refer to. Two children of my own went into the country for three weeks in very bright weather; three others stayed in London, but were made to spend the greater part of the day in a neighbouring open space. The result was that they all got much strengthened and bronzed, and equally so.

When one is "below par"—that is, when one's full vigour is lessened, the lowering influence may almost always be discovered by careful inquiry. It may be over-exertion and too little sleep, or anxiety, or constant family cares, or spending too much time indoors, or living in an overheated room or street, or cold or many other things; but it will be found that in those cases where the change of air is not accompanied by relief from the injurious influence, no good is effected. On the other hand, the benefit that is usually obtained by "a change" may almost always be traced by inquiry to causes much more evident than any difference in the composition of the air. For instance, a woman living in a stuffy house in an ill-ventilated street is rendered languid and oppressed by hot weather. She goes on to a breezy common, and although the temperature of the air there may be nearly the same, its motion about her is much more rapid and constant, and therefore its cooling effect much greater, and she gets correspondingly braced. With "change of air," moreover, people are ready to make changes of habits which they cannot, or have not the force of will to make at home. Thus the circumstances concurrent with "change of air" which act beneficially are usually of a negative character, and consist in the leaving behind some lowering influence. This opinion is not in any way opposed to the fact that the air in different places varies much in its condition (without change in composition), and so is more or less beneficial or detrimental in various diseases and states of constitution.

I am, Sir, yours obediently,

Tunbridge Wells, Edw. G. Gilbert, M.D.
May 29th, 1894.

[The isolated instances referred to by Dr. Gilbert can hardly be taken as sufficient to upset the generally received theory as to change of air. But if those who have charge of schools or institutions would make notes of the effects produced by change of habit on the weight and strength of groups of individuals as compared with other groups taking change of air, we should have something more definite to go upon and the facts accumulated might possibly be of great value to the community.—A. C. Ranyard.]

THE VENOM OF THE VIPERS.

By C. A. Mitchell, B.A.Oxon.

POISONOUS serpents are classified in two main groups—the *Colubrina*, with poisonous fangs permanently erected, and the *Viperina*, nearly all of which have fangs which they can erect or depress at will. The cobra may be taken as the type of the former, while to the latter belong the *Crotalidæ* or rattlesnakes, and the various species of vipers. The *Viperidæ* are distinguishable from the *Crotalidæ* in having no pit between the eyes and the nostrils, but in many other respects they closely resemble each other. The chemical and physiological effect of their venom is also very similar, and presents marked differences to that of the cobra, of which a description was given in a previous paper.

The venom from the common viper (*Pelias Berus*) when freshly obtained is a yellow, viscid liquid which dries into a gummy inodorous mass. As early as the beginning of last century it had attracted the notice of scientific men, for in 1702 we find that a book was published by Dr. Richard Mead called "The Mechanical Action of Poisons," in which he gave an account of his experiments on the viper poison. Misled by the magnified appearance of a drop of the venom when drying, he came to the conclusion that the poisonous principle was due to the presence of caustic saline salts. "These saline particles," he writes, "were now shot out as it were into crystals of an incredible tenuity and sharpness, with something like knots here and there from which they seemed to proceed; so that the whole texture did in a manner represent a spider's web, though infinitely finer and more minute."

This book ran through several editions and Mead's theories were accepted until, in 1767, the Abbé Fontana, naturalist to the Grand Duke of Tuscany, published his classical treatise on viper poison. He proved that no salts were present, as Mead affirmed, and brought forward instead the suggestion that the venom was a natural gum. He also showed that it might be swallowed with impunity by getting his servant to make the experiment on several occasions, the only unpleasant result being a tingling sensation on the tongue, which lasted five or six hours.

In 1843, Prince Lucien Bonaparte obtained an active

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principle from the venom which he called *viperin* or *echidnin*. He also found a yellow colouring matter, a substance soluble in alcohol, albumen, fatty matter, chlorides, and phosphates. This *viperin* was a glittering, transparent mass, containing nitrogen, which detached itself in scales from the glass on drying, and which on injection produced all the symptoms of viper poisoning.

Later research has shown that, as in the case of cobra and rattlesnake poison, the venom of the viper contains more than one albuminoid substance—a *peptone* soluble and incoagulable in water, and a *globulin* coagulable and insoluble.* Dr. Winter Blyth and Dr. Guiseppe Badaloni have independently expressed their opinion that the active principle in the poisons of the rattlesnake and the viper tribe is identical. Though this has not been thoroughly settled, the similarity of the symptoms produced by the poisons makes a close resemblance highly probable.

Five years ago Dr. Weir Mitchell published an account of his later work on crotalus venom, from which it appears that he has been able to separate four albuminoid bodies —three *globulins*, all with different chemical reactions, and one *peptone*. In the case of the cobra he was only able to separate one *globulin* and one *peptone*. The amount of the venom of the Indian viper (*Daboia*) at his disposal was too small for him to prove whether it contained more than one *globulin*. In the venom of the moccasin (*Ancistrodon piscivorus*), however, he found three. Whether the venom of our own viper also contains three, as is very probable, has yet to be determined.

The quantity of the *globulins* present is believed to be of importance, as throwing some light on the different physiological effects of the venoms of different serpents. The crotalus poison was found to contain 24·6 per cent., while in cobra venom only 1·75 per cent. was present. Comparative study of the physiological effects showed that the *globulins* tended to prevent the blood coagulating, while the *peptones* had little power to prevent this, and were the active agents in breaking down the tissues. The *peptone* of the cobra venom also seems to have a more decided power of producing convulsions than the rattlesnake *peptone*.

These observations received corroboration from the experiments of Brunton and Fayrer, who showed that in the case of bites from colubrine or viperine serpents the blood remained fluid—

1. When a large quantity of cobra poison was injected;
2. In the case of viper bites (*e.g.*, the *Daboia Russellii*);
3. Nearly always in the case of man bitten by either;

and that the blood coagulated—

1. When only a small quantity of the cobra venom was injected;
2. In the case of small animals bitten by the cobra.

It thus appears that whereas in the case of viperine venom the blood invariably remains fluid, cobra poison often only partially prevents coagulation, and in some cases not at all. Another important difference is that after the bite of a viper subsequent blood poisoning often follows, while, should there be recovery from the first results of the cobra venom, no such after effect is likely.

If the venoms of the rattlesnake and the common viper be of similar composition, the difference in the virulence of the symptoms produced by them may be accounted for (1) by the difference of climate, and (2) by the much larger quantity of venom which the rattlesnake can inject. Fontana noticed the effect of climate and atmospheric temperature on the power of the viper, pigeons recovering readily on certain occasions. These observations were confirmed by Badaloni in 1883. On December 13th a mouse bitten by a viper died in three-quarters of an hour. On the 17th, when the temperature had fallen to zero, a mouse was placed in a cage with four vipers, which at once attacked it, and in all it received eight bites. It seemed prostrated for some time, but in half an hour was as well as before. In summer a mouse bitten by a viper succumbs in less than ten minutes. Dr. Mitchell has found that cold weather has no effect in diminishing the power of the poison, so that the reptile must lose its power of secretion. The rattlesnake, too, seldom attempts to bite in the spring, and when it does so its venom is milder. Valentin found that confinement had a similar effect. A large viper, after being kept for four months, could not by any means be persuaded to bite. After its death some of the fluid squeezed from the poison duct was found to be almost without effect on frogs. The same happened in the case of other vipers.

There can be no doubt that the quantity of poison injected, and the comparative size and strength of the animal bitten, have much to do with the severity of the symptoms. Fontana found that one four-thousandth of a grain was sufficient to kill a sparrow, while six times as much was required to kill a pigeon. Moreover, animals bitten several times by a viper, or by more than one viper, succumbed much more rapidly than those receiving only one bite. Small dogs were easily killed by a single bite, while larger ones offered much more resistance to the poison, and in many cases recovered. Five bites from three vipers were not enough to kill a dog weighing sixty pounds. From these results he calculated the amount that would be necessary to kill a man. Assuming that the average viper secreted about two grains of the venom, he computed that it would require the entire venom of six vipers to kill an ox and of two to kill a man.

It has been stated that viper venom destroys the life of plants, but the experiments of Gilman are too inconclusive to establish his assertion; and on the other hand, Dr. Mitchell states that there is no reason for such a belief, as does also the French surgeon Viaud-Grand-Marais. It is interesting to notice in this connection that Darwin found that the cobra venom acted as a powerful stimulant to the protoplasm of the cells of the *Drosera*.

All warm-blooded animals are susceptible to the poison, though in different degrees. The cat offers a marked resistance, and has been known to survive bites. Vipers being made to bite each other, which they are very unwilling to do, readily recover, and it has been found that many invertebrate animals suffer no ill consequences. A horse-leech bitten several times by a strong viper was on the following day perfectly well. Snails and slugs also recovered in every instance, the majority covering the bitten part with their viscous secretion.

As in cases of cobra poisoning, the reputed remedies for the bite of the viper are worth very little. Alcohol does not diminish the virulence of the venom, and an alcoholic solution acts as powerfully as the fresh poison. In 1737 the Royal Academy of Sciences of Paris caused experiments to be made to test the efficacy of olive oil as an antidote, and came to the conclusion that it was of no use. Potassium permanganate may be of use occasionally in destroying poison not yet absorbed. In estimating the value of an antidote it should be borne in mind that in the case of the more common European vipers, owing to the small quantity received from a bite, the mortality is very slight, and that therefore recoveries after the use of some special treatment would probably have taken place as well without it. In England it is only those of weak constitution who have much to fear from the bite of a viper, even in the

* See KNOWLEDGE, June, 1894.

hottest months. Unfortunately, the same cannot be said of the bite of the Indian and African vipers, and of the various species of American rattlesnakes.

TYPES OF FLORAL STRUCTURE.

By the REV. ALEX. S. WILSON, M.A., B.Sc.

A FLOWER commonly consists of organs of four different kinds, arranged in concentric circles or whorls. The order in which these organs occur is always the same relatively to the centre of the flower. The carpels forming the gynœcium are most central; next come the stamens composing the andrœcium; outside of these is the corolla, made up of petals, invested externally by the sepals, which collectively constitute the calyx. There is no apparent reason why the carpels and stamens should not occasionally change places, and an explanation of this invariable order is still a *desideratum*.

A second very obvious character of flowers, which admits of better explanation, is the prevalence of certain numbers among the members composing the different whorls. There is a constant recurrence of the same number of parts in the different whorls of the same flower, and in corresponding whorls of different flowers. The number five is exceedingly common. Thus in the violet, with its five sepals, five petals, and five stamens, we have an example of a pentamerous flower. Three is another favourite number, and of this ternary symmetry the iris, with its three sepals, three petals, three stamens, and three carpels, is a good instance.

By founding his classification of plants so largely upon the number of the floral organs, Linnæus gave prominence to this numerical character, and, highly artificial though it be, the Linnæan system has the merit of recognizing the fundamental importance of this feature as an index of natural affinity.

When we study phyllotaxis, or the modes in which leaves are arranged on stems and branches, the reason for the prevalence of certain numbers in flowers becomes apparent. Leaves on a plant's stem are not arranged at random, but according to a definite law. A very frequent arrangement is the alternate, where they are separated by equal spaces or internodes, and so placed that a line drawn through the bases of successive leaves describes an ascending spiral. This line, winding round the stem, is known as the *generating spiral*; the fraction of the stem's circumference which it traverses in passing from one leaf to the next is the *angular divergence*, and the *leaf-cycle* is the portion of the generating spiral included between one leaf and the next above it in the same vertical line. Angular divergence is expressed by such fractions as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, &c., where the denominator indicates the number of leaves encountered, and the numerator the number of revolutions round the stem made, by the generating spiral in completing the cycle—that is, in passing from one leaf to the next above it in the same perpendicular line.

Frequently, though not always, the angular divergence is the same for the stem and branches of the same plant; it is generally constant for the same species, and may even be characteristic of genera and natural orders. A common case is where the leaves are separated from each other by one third of the circumference of the stem; the angular divergence in this case is $\frac{1}{3}$ and the cycle includes three leaves. A still more frequent arrangement gives an angular divergence of $\frac{2}{5}$ with five leaves and two turns of the generating spiral to the cycle. Many plants, again, produce their leaves in pairs, one on each side of the stem; since the vertical planes of the successive pairs commonly cut each other at right angles, this arrangement, well exemplified in the mint and other Labiatæ, is described as opposite and decussate. Three, four or more leaves springing from the same node constitute a whorl or verticil; such a verticillate arrangement is seen in the leaves of the wood-ruff and other Rubiaceæ. The whorling of leaves may be regarded as resulting from the suppression of internodes at regular intervals. A shoot having three leaves placed according to the $\frac{1}{3}$ arrangement would, if we suppose its internodes to remain undeveloped, give rise to a whorl of three leaves; similarly a shoot with an angular divergence of $\frac{2}{5}$ would furnish whorls composed of five leaves if its internodes were suppressed. Hence it is held that each flower whorl represents a compressed leaf-cycle, the number of its constituent parts depending on the leaf arrangement to which it corresponds. The frequency of the numbers 3 and 5 among the organs of the flower becomes intelligible in view of the prevalence among foliage leaves of the $\frac{1}{3}$ and $\frac{2}{5}$ arrangements.

Between phyllotaxis or leaf arrangement and floral symmetry there is thus a very close connection, and we might therefore be led to expect that they would always be in agreement; we might not unnaturally suppose, for example, that every plant with pentamerous flowers should have its leaves arranged on the $\frac{2}{5}$ plan and *vice versa*. Although this rule holds good for many plants, it is very far from universal, and the numerous exceptions point to the conclusion that floral organs have more frequently retained the ancestral phyllotaxis than foliage leaves, which in many cases seem to have departed widely from the primitive arrangement. In other words, the hereditary tendency asserts itself much more strongly in the arrangement of the floral organs than in that of foliage; hence the importance assigned to the flower in every system of classification.

From cases of reversion like the flowering cherry, where the carpels are replaced by ordinary green leaves, we learn that a flower is simply an arrested branch or leafy shoot having its internodes undeveloped and its leaves modified to subserve the function of reproduction. The passage from vascular cryptogams to phanerogams involved, as was shown in a previous article (Vol. XVII., p. 125), the arrest of certain structures belonging to the seed and pollen grain; it now appears that in the formation of the flower we have a further illustration of arrested development.

Excluding the Coniferæ and their allies, which are gymnospermous, all flowering plants have their seeds protected by closed carpels, and are on this account designated angiosperms. Plants embraced under this designation are either monocotyledons or dicotyledons, as the two great classes are called into which angiosperms are divided. To which of these classes a plant belongs can easily be ascertained from its flowers. Each whorl in the flower of a monocotyledon consists of three parts, or of a number which is a multiple of three. The flower of a dicotyledon, on the other hand, is made up of whorls each commonly composed of five parts, or a multiple of five; less frequently, as in the fuchsia and wall-flower, of four, or a multiple of four. Besides this distinction, there is a difference in their floral envelopes; a monocotyledon has the sepals and petals alike—thus in the tulip both whorls of the perianth are coloured or petaloid. Dicotyledons, again, have the sepals mostly green, the petals alone being gaily coloured. The two classes are further distinguished by the characters of their vegetative organs; monocotyledons have parallel-veined leaves, endogenous

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stems and endorhizal roots; the leaves of dicotyledons are net-veined, their stems exogenous, and their roots usually develop in exorhizal fashion. The first leaves of the dicotyledonous embryo arise in a whorl—they are the two opposite cotyledons; the subsequently-formed leaves may arise either in pairs or verticils, but far more frequently they follow the $\frac{2}{5}$ arrangement. There is but one cotyledonary leaf on the embryo of a monocotyledon; in succeeding leaves the $\frac{1}{3}$ phyllotaxis prevails, though $\frac{1}{2}$ is not uncommon.

I. Monocotyledonous Type. II. Dicotyledonous Type.

The persistence of these characters points to an early separation of the primitive angiosperms into two well-defined groups having their leaves differently arranged. Although monocotyledons appear first in the geological series, it is by no means certain that they represent the earlier type. Pentamerous and trimerous flowers may have arisen independently after the separation of the two families, but the leaf systems they respectively represent should at least admit of reference to a common origin. The opposite and decussate arrangement some botanists, with good reason, regard as primary for dicotyledons; from it the $\frac{2}{5}$ and all other divergences occurring in this class can easily be deduced. The two opposite cotyledons favour this view, and the passage from the opposite to the $\frac{2}{5}$ arrangement may be actually observed in the artichoke, willow-herb and other rapidly-growing plants. The $\frac{1}{3}$ type does not admit of direct derivation from opposite leaves, and this Henslow gives as the reason why it is never found among the foliage of dicotyledons; the 3-merous symmetry of such exceptional flowers as *Berberis* he regards as due to the breaking up of a high continuous spiral into groups of threes. The $\frac{1}{3}$ arrangement so characteristic of monocotyledons may have come from the opposite type in this indirect way, through an $\frac{3}{2}\frac{5}{1}$ or more complex cycle; but it is much more probable that it arose by symmetrical decrease. A hint of what was, perhaps, the condition in the common ancestral form is furnished by the herb paris, belonging to a family which has the closest relations with the Liliaceæ. The flowers of *Paris quadrifolia* are 4-merous; its leaves are reticulated and arranged in a whorl of four. We have in this undoubted monocotyledon a combination of monocotyledonous and dicotyledonous characters with a phyllotaxis closely approximating to what in all probability was the primitive type in dicotyledons. It should not be forgotten, however, that in the phyllotaxis of fossil cryptogams and gymnosperms much diversity is found.

In diagrams I. and II. the whorls are shown alternating; this is their normal position. Now since foliage leaves develop in acropetal succession—that is, from below upwards—the floral organs ought theoretically to do the same; but if they followed the strictly spiral succession, the whorls would not be alternate, but superposed. To account for the alternation we must therefore assume that each whorl as a whole has shifted its position, the displacement being equivalent to the rotation of a floral axis through half the angular divergence. The angular divergence itself is observed to change in some flowers; in aconite, for example, from $\frac{2}{5}$ in the calyx to $\frac{3}{8}$ and $\frac{5}{2}\frac{8}{1}$ in the corolla and androecium. One or two of the Ranunculaceæ, such as *Garidella* and *Helleborus*, have the petals superposed to the sepals in strict accordance with spiral phyllotaxis, but this is rare in the floral envelopes. Where the androecium consists of numerous stamens, these are frequently arranged in a spiral manner, giving rise to superposed whorls. The sepals and petals of the buttercup arise in alternate whorls, but the stamens and carpels develop in spiral fashion like ordinary leaves. To this condition the name hemicyclic has been given. In the water-lily order, Nymphaceæ, all parts of the flower follow the spiral order; this condition also occurs in the camellia, in the Magnoliaceæ and Calycanthaceæ, and is approached by several of the Ranunculaceæ. A significant fact in connection with the simplicity of the flower of the water-lily is the circumstance that, notwithstanding its truly dicotyledonous embryo, the root-stock shows the endogenous structure of the monocotyledonous stem.

Considerations like the foregoing make it clear that acyclic flowers, or those whose parts form a continuous spiral, represent a primitive type, upon which the hemicyclic condition of the buttercup is a slight advance. The passage from these to the regular alternating whorls of the eucyclic class involves a modification of the phyllotaxis for each succeeding whorl. Under the term cyclic are included all flowers whose parts occur in whorls, but some confusion has arisen from a lax use of the latter term. Some writers call any set of leaf organs a whorl which arise on the same horizontal zone of the axis—*i.e.*, which are produced at the same height, or what amounts to the same thing, at equal distances from the growing point; others restrict the term to circles in which the parts appear simultaneously. Sepals, as a rule, arise in succession; petals, for the most part, simultaneously. The calyx of the rose illustrates this successive character; its outermost and oldest sepal has fringes on both its edges which are free; so has the second sepal, which is placed at an angle of 144° to the first—*i.e.*, with a divergence of $\frac{2}{5}$. At an equal distance from the second stands No. 3, fringed on its outer edge only; No. 4 is similar, while No. 5, which completes the cycle, has no fringes, both its edges being overlapped by the other sepals. A corresponding order can often be traced even in the corolla—in the butterfly blossoms of Leguminosæ, for example, the large standard petal begins the leaf cycle, one of the keel petals completing it; and generally the æstivation of the flower—that is, the manner in which its parts are disposed in the bud before expansion—admits of explanation on the principles of phyllotaxis. The two examples just given illustrate respectively the quincuntial and vexillary modes of æstivation. As early stages in the evolution of the blossom, then, we have to note: I. The spiral arrangement of the floral organs. II. Whorls due to the arrest of the internodes of the floral axis. III. Alternation, or a change in the orientation of each whorl disturbing the spiral order; and IV. Simultaneous whorls with synchronous development of parts, which still further obscures the original phyllotaxis.

NATURE'S PROTEST AGAINST CHANGE.

By Vaughan Cornish, M.Sc., F.C.S.

THE two great laws of conservation—the law of conservation of mass and the law of conservation of energy—have familiarized the educated world with the doctrine that in Nature nothing is lost. The form of matter changes, but the quantity remains unaltered; the form of energy changes, but its "mechanical

equivalent" is constant—that is to say, the amount of mechanical effect it would produce if the energy were all converted into the motion of a mass of matter. In Nature nothing is lost! Surely no dictum of science was ever more contrary to the voice of common sense—that is to say, the sense of what is reasonable derived from the ordinary experience of life.

Let us take first the law of conservation of mass. It has been the common experience of mankind for ages that solid fuel burns away, producing a certain amount of smoke and leaving a little ash behind, no other substance being formed in the burning. There is nothing else produced which is either visible, tangible, or, as far as common experience goes, ponderable. Common experience failed to afford an insight into the changes in the forms of matter which happen during burning. Lavoisier's *Expèriences* (*vide* KNOWLEDGE, February, 1892) corrected common sense in this, and we now say that in chemical changes no matter is destroyed. Common experience tells us, however, that things have a tendency to wear out and get used up—iron rusts, for instance, and soil loses its fertility. Later chemical research has confirmed this common experience, and shows that the general tendency of chemical changes is to the production of material less capable of reacting chemically, and therefore less available for the work of the world. The carbon chemically combined in plants is still capable of burning, and as a constituent of vegetable food is converted by animals into carbonic acid. Certainly no carbon has been annihilated, but when it has got to the final form of carbonic acid there is little more that carbon can *do*. If it is not lost, it is at all events pretty securely locked up. Were it not for the extraneous energy the earth receives from the sun's rays, the carbon in carbonic acid would be, in this sense, irretrievably lost. In the processes of industrial chemistry we may often see the manufacturer's art applied to the production of some material in a form in which it is chemically active; we may cite, for instance, iron-smelting and alkali-making. Dwellers in the neighbourhood of Middlesborough, or of Widnes, realize better than most people that for every ton of iron a far greater quantity of an effete slag is formed—slag which has accumulated in masses greater than the pyramids of Egypt—and that for every ton of soda there are produced nearly two tons of alkali waste.

The balance of chemical change is on the side of diminished chemical activity. Nature grows weary, and protests afterwards against changes which she does not prevent, and often scarcely hindered at the time.

It is, however, in the domain of physics rather than in chemistry, in transformations of energy more than in transformations of matter, that Nature's protest against change is most strikingly shown. We do not refer merely to the property of inertia, in virtue of which all bodies *resist* a change in their state of rest or motion. In this case, if the resistance be overcome and the motion of the body be increased, energy is stored up in the increased momentum of the body; but when such exchanges of energy are examined in detail there always appears a residual phenomenon which mars the simplicity and completeness of the result. Take the case of any of the well-known mechanical appliances. A small force is made to raise a large weight, and if we multiply the force by the distance through which its point of application is moved the product would be equal to that of the weight multiplied by the distance which the weight is raised, were it not for the inevitable friction which fritters away a part of the mechanical energy in the less available form of heat. It is true that the heat so produced has its mechanical equivalent. Heat can be converted into mechanical work, and one unit of heat converted into mechanical energy produces one thousand three hundred and ninety foot pounds, the same amount of mechanical work which was required to produce the unit quantity of heat; but if we are dealing with the unit quantity of heat, it is found in practice to be impossible to transform the whole of it into mechanical work. Part still remains in the form of heat. Perhaps one half of the unit quantity of heat may be converted into six hundred and ninety-five foot pounds, leaving the other half still in the form of heat energy. This is an example of the conservation of heat energy, but it is a somewhat unsatisfactory form of conservatism, for the half unit of heat which is left is heat at a lower temperature or heat-level than that with which we started, and is less available for further transformation. Only a reduced proportion of this heat can be converted into the higher or more available forms of energy. Hirn's experiments with the steam engine illustrate this point. The loss of heat between the boiler and condenser is accounted for by the mechanical work done, and the mechanical equivalent of heat determined in this way is identical with the heat equivalent of work determined by Joule's method of warming a liquid by the friction of paddle-wheels driven by a falling weight. But the steam engine cannot be worked without a transference of heat between the boiler and the condenser, over and above the heat that is used to overcome resistance. This surplus heat is degraded from the high temperature of the boiler to the low temperature of the condenser. It is still the same in quantity, but it is less available for transformation, less ready to undergo further change. In this case of the running down or degradation of energy an external mechanical effect is produced, and the result is in accordance with our every-day experience, and therefore is consistent with the expectations of common sense. We cannot work without growing tired, and it does not seem unreasonable that something analogous to fatigue should be shown by inorganic nature. But the inorganic world shows loss of vigour, not only after effort, but after any change, even though not accompanied by external effect. It is in such phenomena of diminished vigour, resulting from all those natural changes which proceed without effort and without the accomplishment of work, that we best see Nature's protest against all change. One of the best illustrations, which is not only a striking one, but has been carefully and quantitatively examined, is afforded by the expansion of compressed air into a vacuum. In Joule's well-known experiments, a vessel containing compressed air and provided with a stop-cock was attached to a similar vessel which had been exhausted of air. The two were placed in the same vessel of water, and the temperature carefully noted. The stop-cock was then opened, and the compressed air was allowed to rush into the empty vessel. The empty vessel is thereby heated, and the full vessel cooled; but on stirring the water of the outer or containing vessel so as to equalize the temperatures throughout, it is found that the temperature of the system of bodies has, as a whole, undergone no alteration. The only change is that the energy of the air is less available than it was before. There is the same amount of energy *in* it, but in order to get energy *out* of it we should have to expend work upon it, *e.g.*, by compressing it again into a smaller space. A similar and even more important case is that of the equalization of temperatures which is constantly taking place by the flow of heat from hotter to colder bodies, or from hotter to colder parts of the same body. The amount of heat received by the cold body is equal to that lost by the hot body, but

whereas work, mechanical, electrical, chemical and so forth, could always be got out of the two bodies as long as there was a difference of temperature between them, now that the temperatures are the same no work or effect can be obtained from the interaction of the two.

The tendency of all forms of energy to transform themselves into heat, and the tendency of heat energy to become uniformly distributed and therefore ineffective, is one of the most important modern generalizations from the study of physical forces. A levelling process appears to go on everywhere in the inorganic world, and if the tendencies which are so distinctly seen to operate now are a part of a continuing order of all things, then we cannot avoid the logical conclusion that the world tends towards a state of death in life in which all the mass and all the energy of the present cosmos are undiminished but impotent. Then there shall be no more change.

Such is the dreary prospect afforded by the attempt to push beyond the limits of our experience the conclusions to which observation of inorganic nature undoubtedly leads. What a different prospect is unfolded by the doctrines which have grown out of the scientific study of the animated world! Natural selection, the survival of the fittest, evolution, familiar terms expressing the generalizations of biological science, point to differentiation, development and progress. It is easy to observe the effect of the doctrines of evolution and development in the optimistic tone as to progress and the future of human society adopted by many writers of the present day.

How is it, one may well ask, that the tendency of things appears so different when looked at from the point of view of the physical and of the biological sciences? Perhaps it is that the progress of species, in which the exercise of volition plays an important part, resembles the processes of the industrial arts, in which the finer and more serviceable forms of matter are produced by aid of thought and contrivance rather than the ordinary operations of inorganic nature. We have pointed out how the manufacture of metallic iron involves the simultaneous production of greater quantities of the effete iron slag. Something analogous seems to be indicated in the frightful waste of animal life, and in the extinction of species. Death, however, removes these from the sphere of action —a difference between the organic and the inorganic world, the importance of which will be realized more particularly by those who have studied the processes of chemical change.

Neither should it be forgotten that, after all, the student of physical science deals statistically with the phenomena he investigates, whereas the work of the student of biological science, as the student of mankind also, is to a large extent concerned with individuals. Physical science deals with the properties of energy as exhibited by matter. The units or individuals of matter are atoms and molecules, and we cannot examine individual molecules. Could we do so we might, and probably should, find that the history of any one of the small number of molecules which we might individually study would differ from the history of the body of which they form a part, as much as the fortunes of the individual man may differ from the general lot of the human race. Referring back to the example of the compressed air expanding into a vacuous vessel, it might occur that certain molecules would receive impacts so directed and so timed that their velocity of motion and their individual energy would be greatly increased. If chance directed our attention to such cases, we might be led to suppose that the change which accompanied the expansion of air had been "progressive" in its character, since it acted for the "benefit" of the "fortunate" molecules. But the statistical study of the phenomenon as a whole would show that, in spite of the "development" of individuals, there had been a general lowering of vigour all round.

But, however these things may be, it is undoubtedly the fact that the powers of the animated world are ultimately derived from the inorganic source of physical energy, and sooner or later the powers of organic development must cease if the phenomena of degradation of energy as exhibited by the inorganic world are really, as they appear, universal in their application.

THE FACE OF THE SKY FOR JULY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS show little, if any, signs of decrease. Conveniently observable minima of Algol occur at 11h. 32m. P.M. on the 1st, and at 10h. 3m. P.M. on the 24th.

Mercury is an evening star during the first few days of the month, and a morning star at the end, but is not very well situated for observation in July. On the 1st he sets at 9h. 23m. P.M., or 1h. 5m. after the Sun, with a northern declination of 18° 18′, and an apparent diameter of 9½″, one quarter of the disc being illuminated. On the 6th he sets at 8h. 58m. P.M., or 43m. after the Sun, with a northern declination of 16° 47′, and an apparent diameter of 10½″, $\frac{17}{100}$ths of the disc being illuminated. After this he approaches the Sun too closely to be visible, coming into inferior conjunction with him on the 20th. On the last day of the month he rises at 3h. 24m. A.M., or 1h. before the Sun, with a northern declination of 18° 2′, and an apparent diameter of 9½″, just one quarter of his disc being illuminated. While visible in the early part of the month he is almost stationary in Cancer, to the S.W. of Præsepe, and on the 31st he is again almost stationary in the extreme eastern portion of Gemini.

Venus is a morning star, but, as we observed last month, is becoming rather an uninteresting object for the amateur. On the 1st she rises at 1h. 40m. A.M., or 2h. 9m. before the Sun, with a northern declination of 18° 52′, and an apparent diameter of 14″, three-quarters of her disc being illuminated, and her apparent brightness being about equal to what it was on February 5th. On the 19th she rises at 1h. 35m. A.M., or 2h. 20m. before the Sun, with a northern declination of 20° 38′, and an apparent diameter of 13¼″, $\frac{79}{100}$ths of the disc being illuminated. On the 19th she rises at 1h. 35m. A.M., or two hours and a half before the Sun, with a northern declination of 22° 4′, and an apparent diameter of 12½″, $\frac{82}{100}$ths of the disc being illuminated. On the 31st she rises at 1h. 47m. A.M., or 2h. 37m. before the Sun, with a northern declination of 22° 29′, and an apparent diameter of 12″, $\frac{85}{100}$ths of the disc being illuminated, and her apparent brightness being about equal to what it was on February 7th. She is in conjunction with Jupiter at 8h. A.M. on the 20th, 0° 51′ to the south. During July she describes a direct path through part of Taurus into Gemini, being very near η Geminorum on the 26th, and μ Geminorum on the 28th, being only 0° 3′ south of μ Geminorum at noon on the 28th.

Mars is an evening star in the sense of rising before midnight during July. On the 1st he rises at 11h. 43m. P.M., with a southern declination of 0° 30′, and an apparent diameter of 10·8″, the phase on the preceding limb amounting to 1·7″. On the 10th he rises at 11h. 17m. P.M., with a northern declination of 1° 29′, and an apparent diameter of 11·5″, the phase amounting to 1·8″. On the

20th he rises at 10h. 49m. P.M., or 2h. 45m. after sunset, with a northern declination of 3° 30′, and an apparent diameter of 12·3″, the phase amounting to 1·9″. On the 31st he rises at 10h. 18m. P.M., or 2h. 30m. after sunset, with a northern declination of 5° 28′, and an apparent diameter of 13·4″, the phase on the preceding limb amounting to nearly 2″. During the month Mars describes a direct path in Pisces, being closely *s f* the 5th magnitude star μ Piscium on the evening of the 30th. At about 1h. A.M. on the 17th an 8·0 magnitude star will be $\frac{3}{4}'$ north of the planet, and three or four minutes after midnight on the 29th a 9th magnitude star will be $\frac{1}{4}'$ north of Mars.

Both Jupiter and Neptune are, for the purposes of the amateur observer, invisible.

Saturn is still an evening star, but should be looked for as soon after sunset as possible. On the 1st he sets at 0h. 15m. A.M., with a southern declination of 4° 54′, and an apparent equatorial diameter of $17\frac{1}{4}''$ (the major axis of the ring system being $39\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). On the 16th he sets at 11h. 13m. P.M., with a southern declination of 5° 8′, and an apparent equatorial diameter of $16\frac{1}{2}''$ (the major axis of the ring system being $38\frac{1}{2}''$ in diameter, and the minor $7\frac{3}{4}''$). On the 31st he sets at 10h. 14m. P.M., with a southern declination of 5° 29′, and an apparent equatorial diameter of $16\frac{1}{2}''$ (the major axis of the ring system being $37\frac{1}{2}''$ in diameter, and the minor 8″). Iapetus is at inferior conjunction just before midnight on the 14th. During the month Saturn pursues a short direct path in Virgo through a region destitute of naked-eye stars.

Uranus is also an evening star, but should be looked for as soon after sunset as possible. On the 1st he rises at 3h. 11m. P.M., with a southern declination of 14° 54′, and an apparent diameter of 3·7″. On the 31st he sets at 10h. 50m. P.M., with a southern declination of 14° 53′. He is almost stationary in Libra during the month. A map of the stars near his path will be found in the *English Mechanic* for March 23rd.

Shooting stars are fairly numerous in July, though twilight interferes with observation. A well-marked shower radiates from near δ Aquarii, the maximum being on the 28th. The radiant point is in 22h. 40m.—13°.

The Moon is new at 5h. 45m. A.M. on the 3rd; enters her first quarter at 10h. 15m. P.M. on the 9th; is full at 10h. 3m. P.M. on the 17th; and enters her last quarter at 9h. 7m. P.M. on the 25th. She is in perigee at 2h. P.M. on the 3rd (distance from the earth 225,215 miles), is in apogee at 3h. P.M. on the 17th (distance from the earth 252,460 miles), and is in perigee at 11h. P.M. on the 31st (distance from the earth 222,280 miles). At 8h. 42m. P.M. on the 17th the 5th magnitude star A Sagittarii will disappear at an angle of 55° from the north point, and reappear at an angle of 286° at 9h. 52m. P.M. At 8h. 55m. P.M. on the 18th the 6th magnitude star B.A.C. 7197 will make a near approach at an angle of 346°. At 10h. 33m. P.M. on the 20th the 6th magnitude star 50 Aquarii will disappear at an angle of 354°, and reappear at 10h. 57m. P.M. at an angle of 315°. At 2h. 1m. A.M. on the 21st the $6\frac{1}{2}$ magnitude star B.A.C. 7835 will disappear at an angle of 47°, and reappear at 3h. 20m. A.M. at an angle of 241°. At 11h. 30m. P.M. on the 25th the 6th magnitude star 19 Arietis will disappear at an angle of 60°, and reappear at 0h. 25m. A.M. on the 26th at an angle of 243°. At 3h. 40m. A.M. on the 27th the $4\frac{1}{2}$ magnitude star ζ Arietis will disappear at an angle of 117°, and reappear at 4h. 18m. A.M. at an angle of 186°. At 11h. 51m. P.M. on the 27th the 6th magnitude star 36 Tauri will disappear at an angle of 126°, and reappear at 0h. 20m. A.M. on the 28th at an angle of 197°

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of June Problems.

No. 1 (By Mrs. Baird).

Key-move—1. Q to KR8.

If 1. . . . K×P, 2. Q to B6.
1. . . . K to B4 2. Q to R5ch.
1. . . . P×P, 2. Kt to B5ch.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha, J. Perkins, A Norseman, W. Willby, B. G. Laws, E. W. Brook, J. St. L. Kirwan, Chat.

No. 2 (By C. D. Locock).

1. Q to B5, and mates next move.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha, J. Perkins, J. E. Gore, W. Willby, B. G. Laws, E. W. Brook, J. St. L. Kirwan, G. G. Beazley, Chat.

ADDITIONAL SOLUTION of Mr. De Morgan's problem received from J. St. L. Kirwan.

J. Perkins.—There is no Solution *Tourney* in KNOWLEDGE at present, but solutions will always be acknowledged.

Yum-Yum.—This page was in the printers' hands when your letter arrived last month.

E. W. Brook.—Much regret that you decided not to take part in the adjudication. Your previous experience of most of the positions published in this and other columns was surely a sufficient qualification. Solutions of Nos. 1 and 2 are quite correct.

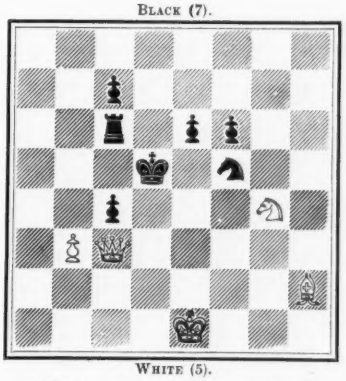
Many correspondents have congratulated us on the success of the Solution Tourney, and on the high standard of the problems in it. We have to thank them also for many discriminating criticisms of the problems, and regret that we have not space for their publication. Some of their ideas, however, will be found embodied in our brief criticism of the less fortunate problems. The more fortunate, of course, cannot be criticized in print till the judge has decided on their respective merits.

PROBLEMS.

By A. C. CHALLENGER.

No. 1.

BLACK (7).

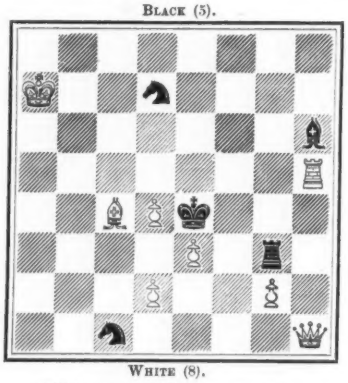


WHITE (5).

White mates in two moves.

No. 2.

BLACK (5).



WHITE (8).

White mates in two moves.

KNOWLEDGE PROBLEM TOURNEY.

Only seven took part in the preliminary adjudication, viz., J. H. Christie, A. C. Challenger, Semper, A Norseman, Chat, Guy, and the Chess-Editor. Marks, awarded on the plan given last month, were divided among the various problems as follows:—44½, 37½, 34½, 33½, 28, 27½, 26½, 25½—13½, 10, 8, 5, 0, 0, 0. Total 294=7×42. As the voting was very close, and the gap obviously comes after the first eight, the Chess-Editor decided that these eight problems ought to go before the judge. The eight successful problems, named in the order of publication, are —No. 2 ("*I can't help your troubles*"), No. 3 ("*Sweetness and Purity, &c.*"), No. 4 ("*Stella*"), No. 5 ("*Bonne Bouche*"), No. 10 ("*Nulli Secundus*"), No. 11 ("*Pearl of the Garden*"), No. 14 ("*Enrichetta*"), and No. 18 ("*Fortes fortuna juvat.*")

Chat and the Chess-Editor alone placed seven of these on their lists, A. C. Challenger, Semper and Guy placing six. The problem which obtained 37½ marks was the only problem on every list. One solver placed it first, while no less than three placed it seventh.

Mr. E. N. FRANKENSTEIN has kindly accepted the post of judge. We expect to publish his award next month.

CRITICISMS.

No. 1 ("*Pro virtute*").—Spoilt by the weak key and dual. The construction is a little clumsy, but there are some creditable variations.

No. 8 ("*Morceau*").—Neat and unpretentious. The dual short mate is a drawback.

No. 9 ("*Lieblich sind, etc.*").—In spite of the weak key and crowded forces, the author's idea of meeting 1. . . P to B5 by 2. Q to Kt7, resulting in three absolutely pure mates, is perhaps the finest in the whole tourney. Unfortunately, there is a dual in this the main variation.

No. 12 ("*Slender*").—Pretty and elegant, with a fairly good key, and one quiet second move. But like No. 8 it is rather a light weight.

No. 13 ("*Invicta*").—Some nice variations; but the symmetrical construction makes the key obvious, and not only halves the variety but doubles the dual.

No. 16 ("*A Norseman*").—A fair key, but the duals leave only two sound variations.

No. 17 ("*Posuit ultimum lapidem*").—Rather a crowded position. The triple and dual completely spoil an otherwise fairly good position.

Of the unsound problems, "*La Retraite*" was perhaps the best; "*East Harling*" had a fine strategical key; "*The Circle*," if sound, would probably have been the most difficult problem in the tourney.

CHESS INTELLIGENCE.

The result of the Championship Match was received too late to report last month. Mr. Lasker won the last game in fifty-two moves, and the match by ten games to five and four draws, almost the identical score by which Steinitz himself defeated Zukertort in their last match. It is stated that the loser has issued a challenge for a return match to be played under similar conditions next December. In the meantime Mr. Lasker, who is expected in Europe shortly, must be considered champion of the world. Till quite recently it was the fashion to minimize in every possible way the merit of Mr. Lasker's successes, though exactly two years ago an opinion was expressed in KNOWLEDGE that he had no equal in Europe except Dr. Tarrasch. Now his reputation rests on a securer basis. To what extent Mr. Steinitz's defeat is due to increasing years and ill-health cannot be accurately determined; but, as is well known, his victories during the last few years have not been marked by those crushing majorities to which we were accustomed fifteen years ago. He defeated Gunsberg and Tschigorin by a very small margin of games, and subsequently lost both games in his match by correspondence with the latter player. It is extremely improbable, therefore, that he was quite at his best this year. The internal evidence of the games shows inequality of play and a certain lack of patience, though at times there was much of the old brilliancy.

The Championship of the Southern Counties' Chess Union has fallen to Surrey. After their victory in the south-eastern division the result was practically decided, though they still had to play matches with Northamptonshire and Gloucestershire, both of which counties they defeated without much difficulty.

Mr. Teichmann has considerably added to his reputation by two consecutive victories in tournaments at Simpson's Divan. Messrs. Bird, Müller and Rolland were among the competitors.

On May 26th the City of London Club defeated a strong team of the St. George's Chess Club by the decisive majority of eleven and a half to three and a half. Mr. Wayte was the only prominent absentee on the defeated side.

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